MACHINE DESIGN

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ALLIS-CHALMERS

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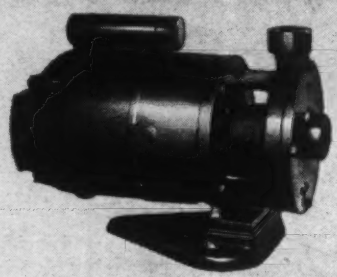
Easy-to-Install pumps

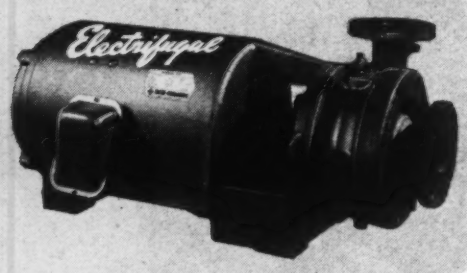
Fit Most Designers' Needs



FHP pump

Up to 80 gpm, heads to 125 feet.

Compact pump and motor requires only two bolts for installation. Rigid construction holds alignment for longer bearing and seal life. Mechanical seal. Open impeller economy model does adequate job on many installations at very low cost. Closed impeller model for higher heads. Also available as frame-type pump for separate mounting.



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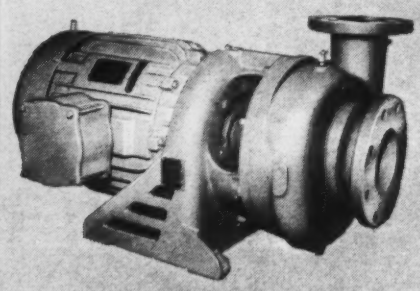
Only pump with unit-cast frame. Motor and pump are mounted on a single shaft in a one-piece rigid cast-iron frame. Alignment is rigidly held but there is plenty of space for maintenance. Installation requires only four bolts. Standard packing or mechanical seal available. Also built as frame-type pump for separate mounting.



Supporting adapter pump

Up to 2500 gpm, heads to 550 feet.

Flange motor and pump mounted on sturdy cast-iron supporting adapter. Motor and pump use same shaft. Rigidity assures vibrationless operation and long bearing life. Only four bolts required for installation. Available with standard packing or mechanical seal. Built in same ratings as frame-type pump for separate mounting.

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A-3969

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MACHINE DESIGN

MAY 1953, Vol. 25—No. 5

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Over the Board

Contemporaneously in Strive?

Engineers have the reputation of being smart people but not exactly cultured. In fact, they are not even expected to be able to write well, and a few engineers accept and glory in their clumsiness in expression. However, as editors primarily engaged in processing manuscripts prepared by engineers, we feel qualified to say that by and large engineers are good writers. Not being a literary magazine we don't look for a high degree of elegance in style, though we do expect clarity and the correct use of words. Once in a while, though, we get the elegance but not the clarity as this concluding sentence of a rejected manuscript shows: "As the man of many backgrounds and experieces, he the gage Engineer, must keep contemporaneously in strive with the congenitally of modern machine progress and associate methods of production and visualizations."

This Month's Cover

A critical area in the design of instruments is that of fine-pitch gearing. The article beginning on page 120 in this issue shows how principles of statistical analysis can be used to obtain satisfactory limitations on backlash without unnecessarily restricting the accuracy or production of the individual gears in a train. With this article in mind, we asked Penton cover artist George Farnsworth to depict generally the overall area of machine instrumentation. We hope you like the result.

Our Backbone

That element of our exterior that connects the front and back covers and holds the book together is very appropriately called the backbone. With our type of binding it provides a useful space to record the volume and issue numbers, date, and name of the magazine, so they will be visible when several issues are stacked together. You may have noticed the new modern look of our backbone, which began last month. One improvement is the addition of a bold issue number which is seen right side up with vertical stacking. The other is a bit of color to help you identify MACHINE DESIGN.

Monthly Index

It has been said that if an authority writing a reference work is too busy to compile the index, he should "farm out" the writing and do the index himself. Which is another way of saying that without a good index to point the way, such a work loses much of its value. We have always gone along with this thought and in fact pioneered the idea of a single "Itemized Index" covering both editorial and advertising pages, a continuing feature of MACHINE DESIGN since its earliest days. The increasing size of each issue (last month's reached an all-time record with 508 total pages) has made it necessary to expand the monthly index to two pages (see Pages 7 and 10). The extra space also enables us to include more items and cross references, so we believe our Index is now twice as effective as before.

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MACHINE DESIGN
MAY 1953

By Deeds and Attitude

RECENTLY we were asked to comment on whether "the deteriorating moral sense of the American people" has contaminated the engineering profession. Whether or not the moral sense of the people as a whole has actually deteriorated, the question is important because our work as engineers touches everybody to an ever-increasing degree and our actions as engineers and as citizens can exert a powerful influence on the community. We say "can" advisedly because we do not think that engineers as a group exert as much influence as other professional groups.

As engineers, we are being constantly urged to work toward professional recognition so that we can extend our influence. Often the medical and legal professions are held up as shining examples of how public acceptance of and respect for a profession can be built up by proper organization. It was even suggested on this page a short time ago that engineers take at least one leaf out of the doctors' book.

The individual engineer, employed in industry, may find it a little hard to tie in such vague terms as "service to humanity" and "social responsibility" with his daily work. What, then, can he do to enhance respect for his profession? He does not deal directly with the general public, like the doctor, nor does he work in the public eye like the lawyer. Instead, his work touches the public through the products which he designs and which the public uses or sees in use. That is where his influence can be felt and where he has a direct responsibility to serve mankind—through the integrity of his work.

Integrity can be built into a machine just as surely as it can be developed in human relations. The persistent effort, hard study and extra hours necessary to develop the best design rather than the most expedient, plus a refusal to compromise on quality of materials and components, are among the elements of integrity in design. Unyielding insistence on integrity is not easy but it should be recognized as the hallmark of the engineer both by the company for whom he designs machines and by the ultimate users.

Thus by deeds and a professional attitude, rather than by vague talk about social responsibility, engineers can develop in a practical manner further steps toward true professional recognition and influence. There is here a unique opportunity to set standards of professional conduct that will earn the respect of the layman and give other professions something toward which to strive.

Colin Carmichael

EDITOR

By W. L. Healy and C. H. Bayer
Switchgear Dept. *Engineering Services Div.*
General Electric Co. *General Electric Co.*
Philadelphia, Pa. *Schenectady, N. Y.*

SIMPLIFIED DRAFTING PRA

Increased efficiency and productivity in the preparation of engineering drawings are attainable through a cost-conscious program aimed at elimination of needless details

CURRENT shortage of designers and technical draftsmen, coupled with the prospect of no immediate relief, makes their continuous employment at highest levels of skill more necessary than ever. To accomplish this end, activities which deprive them of the opportunity to make full use of their technical training, experience and ingenuity should be eliminated from daily assignments. The really important part of any designer's or draftsman's job is thinking—the picture part of drafting is incidental. Thus, when only required to do necessary drawing as simply as possible, more time is available for greater self-expression, and productivity.

During the past twenty years, there has been little change in drafting techniques. Drawings prepared today do not differ widely from those produced two decades ago. In nearly every other line of business and industry, radical time-saving improvements have been introduced. Those systems, routines and machines which were in use in the late 1920's are nearly all obsolete. Business machines have helped to replace the old-fashioned bookkeeper. With the help of accounting machines, industrial and commercial paper work is processed rapidly. Clerical routines have been streamlined with the introduction of modern office equipment and by the application of more efficient methods and systems. Yet little has been accomplished by way of systematically eliminating unnecessary work in drafting operations.

Early in 1947, a critical analysis of the activities of Switchgear Dept. draftsmen was begun and since then, objective thinking has been encouraged relative to planning and executing the work done at the board. This has resulted in a program, termed "value consciousness," aimed at removing from drafting operations anything that does not contribute to the usefulness of the drawings required. Every assignment

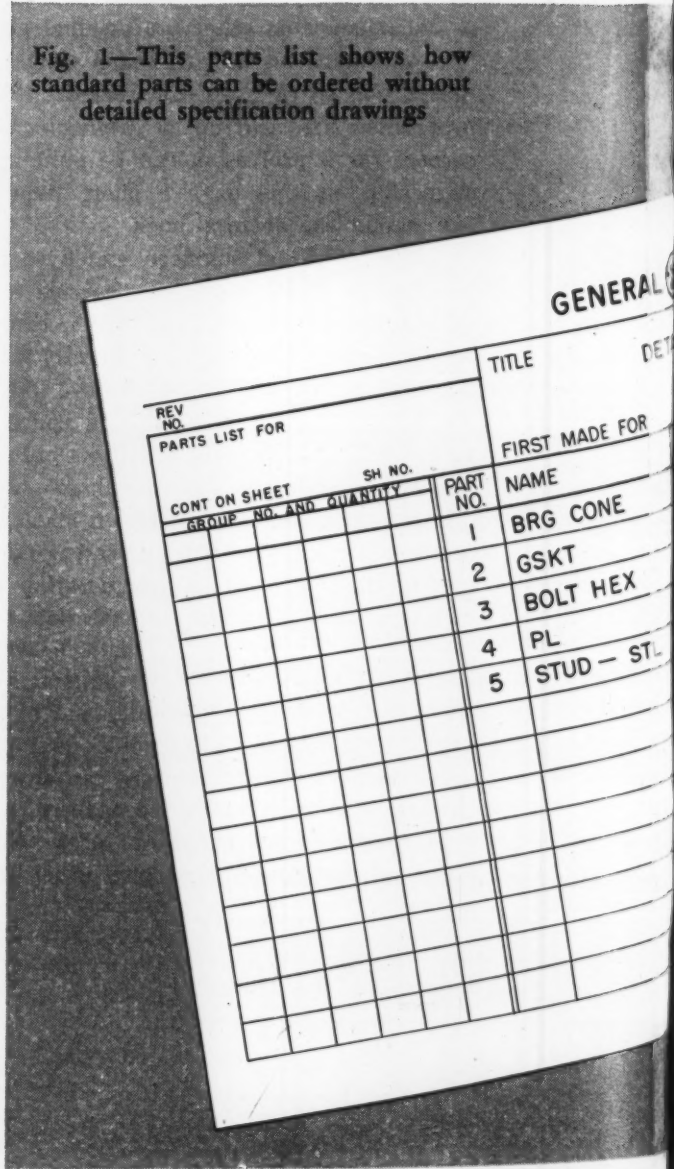
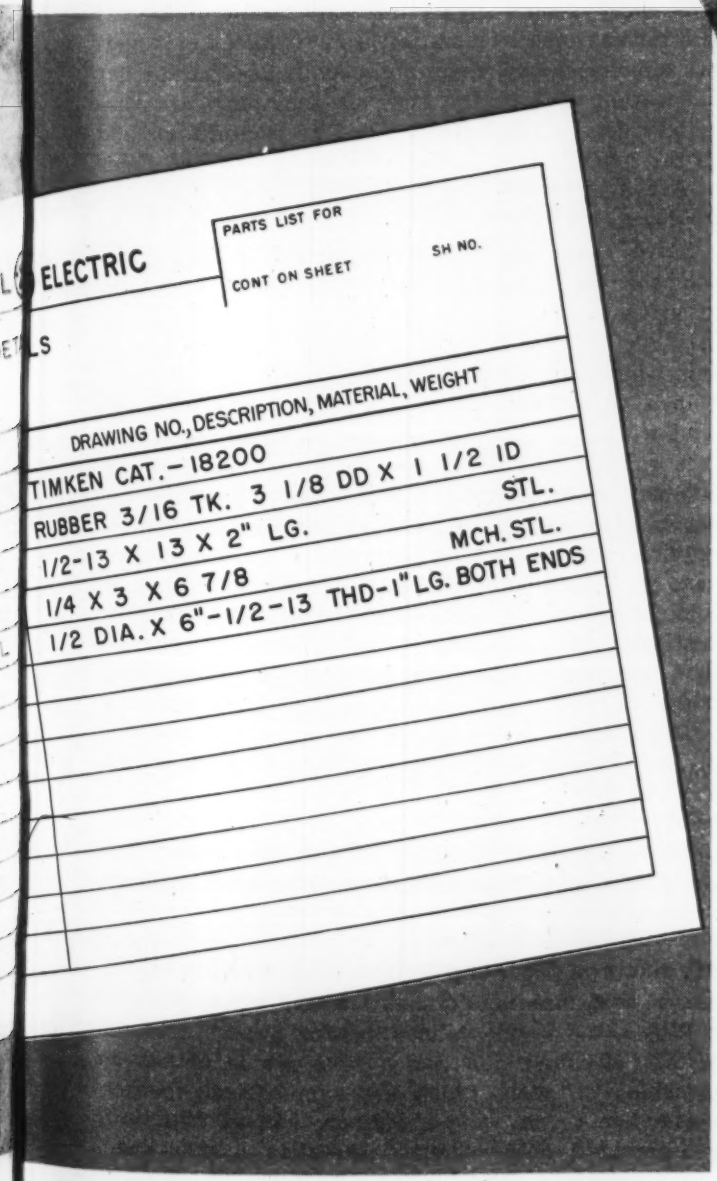


Fig. 1—This parts list shows how standard parts can be ordered without detailed specification drawings

Based on the forthcoming book, *Simplified Drafting Practice*—W. L. Healy and A. H. Rau, John Wiley & Sons, Inc., New York.

ACTICE


ELECTRIC
PARTS LIST FOR
CONT ON SHEET
SH NO.
DRAWING NO., DESCRIPTION, MATERIAL, WEIGHT
TIMKEN CAT. - 18200
RUBBER 3/16 TK. 3 1/8 DD X 1 1/2 ID
1/2-13 X 13 X 2" LG. STL.
1/4 X 3 X 6 7/8 MCH. STL.
1/2 DIA. X 6" - 1/2 - 13 THD - 1" LG. BOTH ENDS

is examined carefully in order to plan for the preparation of only those drawings which are necessary to meet the overall requirements. Further, every designer and draftsman is urged to accept the responsibility of eliminating from drawings any delineations which are unnecessary and which do not contribute to economical manufacture, installation or maintenance of the product.

Establishing the Essentials: It has been proved that within a three year period as much as a 20 per cent increase in drafting productivity is possible when all of the known principles of simplified drafting are employed. A study of typical drafting activities usually reveals that full time is not always applied to the type of work for which men are trained. In other words, design and drafting skills are not always being utilized because of routine assignments which could be delegated to clerical help. Available time can be used much more efficiently by extracting from the job those functions which do not contribute to the

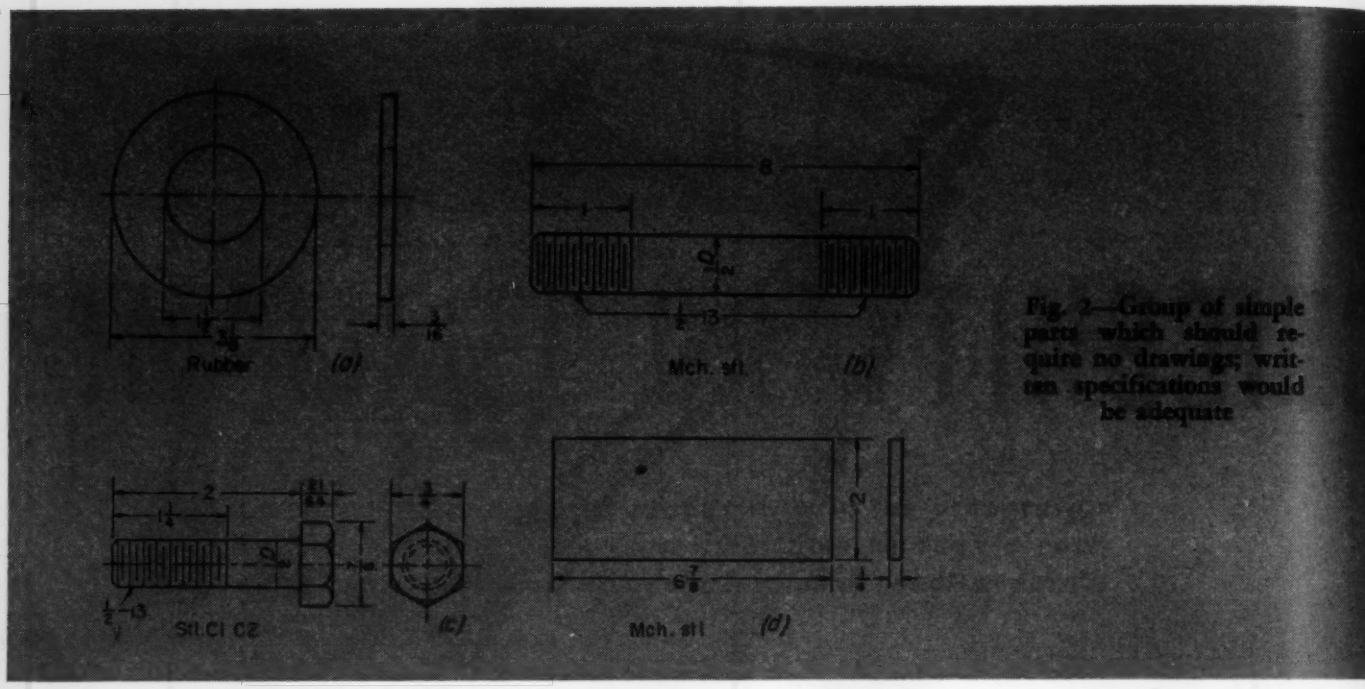


Fig. 2—Group of simple parts which should require no drawings; written specifications would be adequate

normal design and drawing assignment.

Frequently draftsmen are called upon to maintain voluminous records and files. Much time is often spent searching for prints, writing long-hand lists, meticulously lettering bills of material, etc. Much of the lettering now being done by hand could be more legibly accomplished by typists using modern typewriters. Preparation of drawing change bulletins, instructions for correcting parts in process, charts, graphs and nontechnical material can easily be prepared by trained clerical personnel.

Preplanning the Drawing: When the draftsman is encouraged to preplan the job at hand, there is no limit to the possibility for effecting reduction in drafting costs. Preplanning is synonymous with objective thinking and constructive questions should be raised, such as:

1. Why make this drawing?
2. What information must be conveyed?
3. Who will utilize this information?
4. Can the information best be furnished in the form of a drawing?

The man employing such mental processes develops a "value consciousness" habit. He will naturally begin to consider the logic in eliminating all unnecessary work unless it actually contributes to the information he plans to transmit. His first consideration will be how simple he can make the drawing without sacrificing clarity and without chance of misinterpretation.

When the little habits of objective thinking become the practice of any organization, savings in drafting cost are realized daily, and are compounded as the idea of simplification spreads from one man to another, thence from one group to another.

Eliminating the Unnecessary: Adequate preplanning of a design job eliminates unnecessary drawings. Standard parts such as gears, hardware, pipe fittings and many similar items are adequately illustrated and dimensioned in manufacturers' catalogs or standard handbooks and, therefore, usually need no further delineation. Frequently, however, such parts are completely detailed on drawings and as such do not add to the general information conveyed. The five items of *Fig.* 1 illustrate how parts can be ordered without further delineation.

As an example of an unnecessary drawing, *Fig.* 2*a* shows a rubber gasket that could have been described by a few words. It is just as clear to write "$\frac{3}{16}$ thick by 3⅛ OD by 1½ ID Rubber." *Fig.* 2*b* shows the full delineation of a steel stud 8 inches long, threaded 1 inch on either end. The workman producing the stud will understand immediately what is required if it is specified as, "½ dia. by 8 long, threaded ½-13, 1" on each end—machine steel." Regarding the bolt shown at *c, Fig.* 2, no further information would be required to procure this part than, "½-13 by 2 long hex. hd. bolt, Steel C1C2." Frequently drawings contain delineations of parts which require no further operations such as *Fig.* 2*d*. It is immediately apparent that this drawing is unnecessary when the material is described as, "¼ by 2 by 6⅞—machine steel."

The value-conscious draftsman will be on the alert also to eliminate unnecessary lines from drawings. *Fig.* 3*a* shows a simple steel part with three tapped holes. The delineation of these holes, together with the side view projection, are entirely unnecessary and the part may be drawn as shown simplified. All unnecessary dotted lines and views which do not tell a story, should be eliminated. An end view, such as the one shown in *Fig.* 3*b,* may be omitted when the shape can be described as hex, square, round, etc.

Why draw a full delineation for symmetrical objects? It is not uncommon to see such details on drawings of parts which are symmetrical about a center line. A drawing of only one-half of the object, containing a note "symmetrical about center line,"

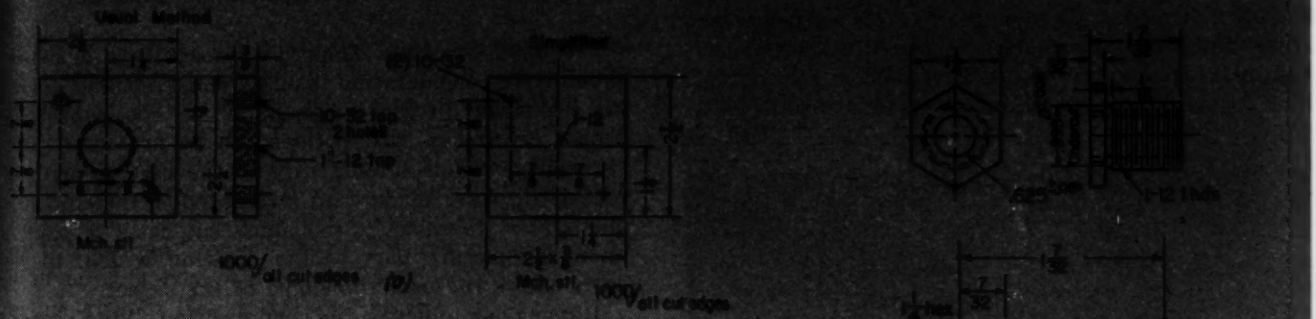


Fig. 3 — Drawings of two typical parts and simplified views to eliminate unnecessary lines

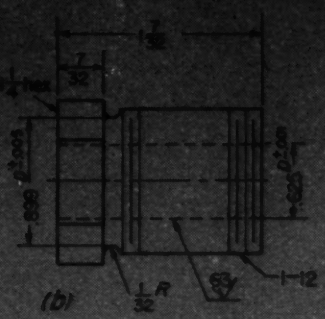
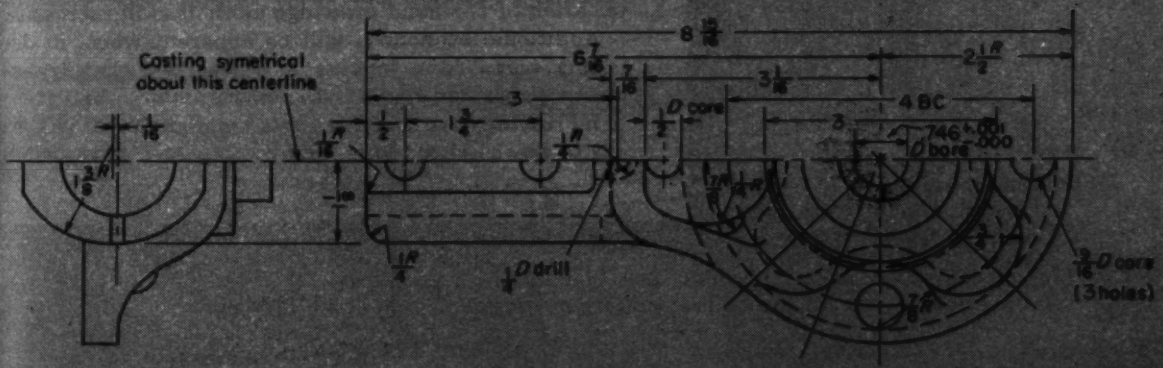


Fig. 4—Symmetrical parts such as this casting can be shown in one-half detail



would save the draftsman about half of the time required to draw the full view. A typical example, shown in *Fig.* 4, is the plan view of a casting. Other views and sections are necessary, of course, to give complete information for the making of the pattern.

Assembly drawings are usually made for the purpose of assembling parts in their proper place. As a general rule, it could be said that enough detail should be shown on the drawing to enable the workman to readily recognize and install the parts without having to make inquiries—no more; no less. More drafting than necessary is a waste of time; less would make the drawing useless. On assembly drawings, parts are usually identified by cross-reference numbers to other drawings on which the parts are fully described. A typical example is shown in *Fig.* 5*a*. Parts 11 and 17 are fastened together by a bolt, part 77. A flat washer, part 84, is placed under the head and a lockwasher, part 67, is assembled under the nut, part 35. Parts 11, 17, 35, 67, 77 and 84 are adequately described elsewhere. A glance at *Fig.* 5*b* shows their exact relationship. Since parts 77 and 84 are shown on one side, there is no chance of improper assembly as the bolt, part 77, is inserted from this side.

While the example is quite simple, it develops a whole new scope of thinking. Drafting time can be saved by objectively analyzing an assembly requirement before beginning the work. Obviously, at the time the drawing is used, all of the parts will have been fabricated and only the simplest drawing is necessary to assemble correctly the component parts. This objective analysis will assist in determining those few lines needed on an assembly drawing, yet will assure full awareness of the assembler's requirements.

Certainly there is much detail and elaboration as shown in *Fig.* 6*a* which could be omitted from the drawing without confusing the workman. Considering the purpose for which the drawing is being made, *Fig.* 6*b* will serve just as well.

Another type of drawing, usually with far too much elaboration of detail, is the so-called "outline" which is generally prepared to furnish limiting dimensions, mounting provisions, etc., of a piece of equipment. Planning objectively and once more considering the purpose for which the drawing is to be used, all minute

detail and elaboration, which add nothing to the instructions or information required, can be eliminated. The user is usually only interested in such data as overall dimensions, floor plans, clearances, inspection areas, and other information required for installation and maintenance. He is not interested in a beautiful, time-consuming or artistic drawing embellished with details or several accurately projected unnecessary views. These add nothing except to the cost of the drawing and, hence, to the cost of the product.

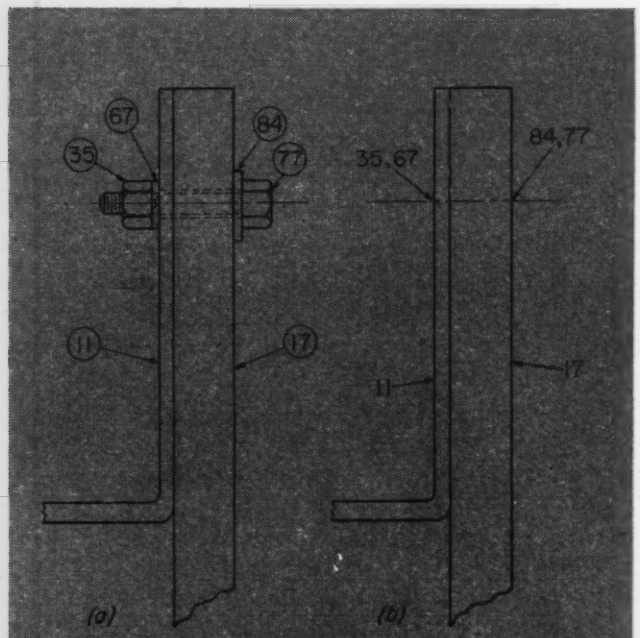


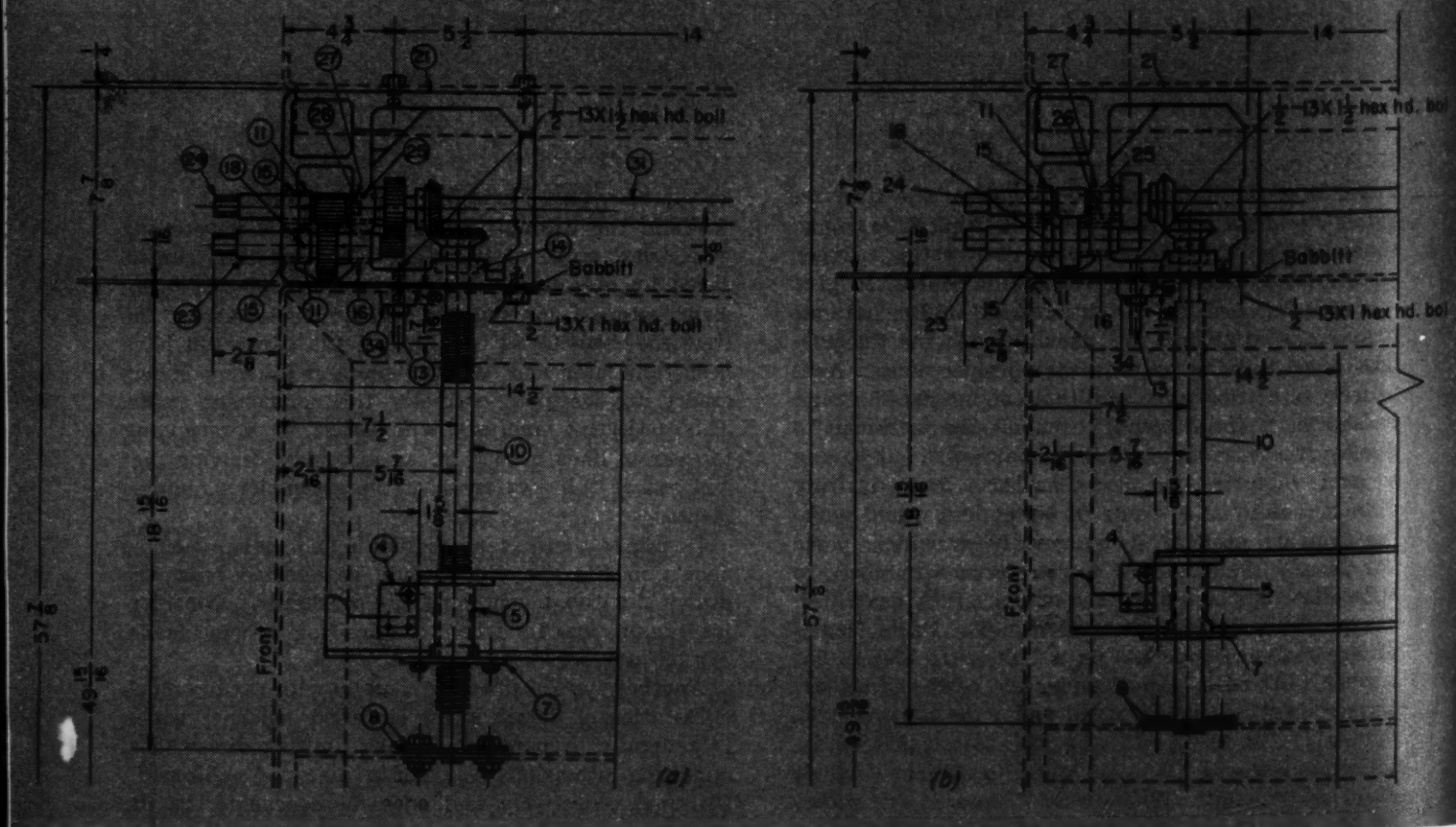
Fig. 5—Above—Typical assembly drawing, *a*, and simplified version, *b*

Freehand Drawing: Modern approaches to drawing should give consideration to employing freehand drawing whenever, in the judgment of the cost-conscious design draftsman, instructions can be presented just as clearly and as intelligently to the user as with a precise drawing made with straightedge, instruments and scale. Frequently, too much emphasis is placed upon the picture part of the drawing which, to be sure, shows the user the shape of the object.

Dimensioning defines the configuration of the object. Obviously, when dimensions are added to a freehand drawing, as shown in *Fig. 7a*, it is just as accurate and just as complete as when the same dimensions are added to the mechanically made drawing shown in *Fig. 7b*. Although the illustration is simple, the procedure can be extended to more complex work. If the first shock of putting a regular number on a freehand drawing, made on a standard form, is survived, measurable economies in drafting will result. Designers and draftsman will naturally expand the field for application of freehand drawings as their skill increases.

Additional economies will be apparent when, in detailing parts from layouts, it is realized that translucent paper can be placed over the layouts and freehand tracings made of the parts being detailed. As an aid to freehand drawing, many companies have print-

Fig. 6—Below—Machine assembly drawing, *a*, which requires a certain amount of detail can still be simplified considerably as at *b*



ed, nonactinic cross-section lines on drawing forms. The cross-section lines will not be transferred to the blueprint reproductions of the tracing.

Abbreviations: Attractive savings can be realized by using abbreviations on drawings, manufacturing papers, planning cards, etc. Some have taken the attitude that unless all terms and words are spelled out, an element of risk is introduced which will lead to misinterpretation. However, abbreviations when restricted to those terms and phrases used universally, or to those used repetitively, or which are peculiar to a given company, will effect economies worth considering without loss of drawing utility.

Engineering Societies have been aware of inherent savings in both drawing space and drawing time resulting from the use of abbreviations. Accordingly, the American Standards Association, under the joint sponsorship of the AIEE and the ASME have prepared a Standard Z-32.13-1950, entitled "Abbreviations for Use on Drawings." The committee charged with the preparation of this standard collaborated with the Military at all stages during the development. The ASA Standard contains abbreviations for approximately 2400 terms, words and phrases frequently

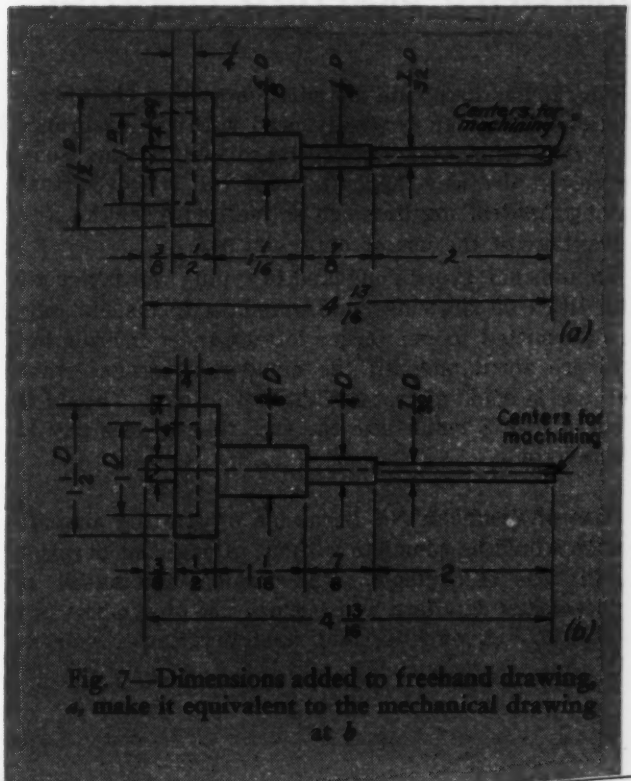


Fig. 7—Dimensions added to freehand drawing, *a*, make it equivalent to the mechanical drawing at *b*

GENERAL ELECTRIC

REV. NO.
PARTS LIST FOR
CONT ON SHEET SH NO.
GROUP NO. AND QUANTITY

TITLE AIR CIRCUIT BREAKER COMPT.
FIRST MADE FOR

PART NO.	NAME	DRAWING NO., DESCRIPTION, MATERIAL, WEIGHT
1	ASSEMBLY	
2	ASSEMBLY	
3	ASSEMBLY	
4	ANGLE	2 X 1 1/2 X 1/4 X 22 7/8 STEEL
5	ANGLE	2 X 1 1/2 X 1/4 X 72 7/8 STEEL
6	SIDE SHEET	3/16 X 20 X 30 SHEET STEEL
7	CLIPS	B-11 K-0000000
8	CRANK	G-2 T-0000000
9	SIDE SHEET	3/16 X 20 X 30 SHEET STEEL
10	TRANSFORMER COMPT	P-11 K-0000000
11	FLOOR PLATE	1/8 X 44 3/4 X 72 1/8 SHEET STEEL
12	CLIP ANGLE	1 1/2 X 1 1/8 X 1/4 X 1 1/2 STEEL
13	BEARING BRACKET	P-3 M-0000000
14	TOP COVER	1/8 X 36 X 44 3/4
15	CLAMP SCREW	K-0000000
16	ANGLE	1 1/2 X 1 1/2 X 1/4 X 13 1/2
17	ANGLE	1 1/2 X 1 1/2 X 1/4 X 22 1/4
18	CHANNEL	4-7.25#/FT. X 35 STEEL
19	AIR CIRCUIT BREAKER	T-0000000
20	CONNECTION DIAGRAM	P-0000000
21	CONDENSER VALVE	
22	CONDUIT BOX	
23	FUSE	G.E. CATALOG 1472
24	SHAFT EXTENSION	G-6 00

(a)

GENERAL ELECTRIC

REV. NO.
PARTS LIST FOR
CONT ON SHEET SH NO.
GROUP NO. AND QUANTITY

TITLE ACB COMPT.
FIRST MADE FOR

PART NO.	NAME	DRAWING NO., DESCRIPTION, MATERIAL, WEIGHT
1	ASM	
2		
3	ASM	
4	ANG	2 X 1 1/2 X 1/4 X 22 7/8 STL
5	ANG	2 X 1 1/2 X 1/4 X 72 7/8 STL
6	S SH	3/16 X 20 X 30 SH STL
7	CLIPS	B-11 K-0000000
8	CRK	G-2 P-0000000
9	S SH	3/16 X 20 X 30 SH STL
10	TRANS. COMPT.	P-11 K-0000000
11	FL PL	1/8 X 44 3/4 X 72 1/8 SH STL
12	CLIP ANG	
13	BRG BRKT	P-3 M-0000000
14	TOP COV	1/8 X 36 X 44 3/4
15	CLP SCR	K-0000000
16	ANG	1 1/2 X 1 1/2 X 1/4 X 13 1/2
17	ANG	1 1/2 X 1 1/2 X 1/4 X 22 1/4
18	CHAN	4 - 7.25#/FT. X 35 STL
19	ACB	T-0000000
20	CONN DIAG	P-0000000
21	COND V	
22	CND BOX	
23	FU	G.E. CAT. 1472
24	SFT EXT	G-6 P-0000000

(b)

Fig. 8—Typical parts list is shown at *a* while that at *b*, utilizing abbreviations, not only permits larger characters but requires less time to produce

used. It has had wide distribution so that the abbreviations listed can be freely used with the assurance that they will be understood by all industries. Cost-conscious drafting organizations will discover that savings in drafting time can be realized by taking full advantage of the use of abbreviations.

In addition, typists engaged in typing words, legend and titles on drawings and standard forms not only are permitted to use larger letters and numerals but will use about one-half the number of strokes when full use is made of standard abbreviations. The parts lists in *Fig.* 8 emphasize the fact that it does pay to abbreviate.

Use of Symbols: No discussion of drafting simplification would be complete without giving consideration to the use of symbols. The possible elimination of unnecessary detailing by extended use of symbols is a fertile field for effecting additional drafting economies.

graphical symbols for use on drawings are:

1.	Architectural	Z-32.9
2.	Graphical Symbols on Mechanical Drawings	Z-32.2
3.	Pipe Fittings	Z-32.2.3
4.	Graphical Welding Symbols	Z-32.2.1
5.	Single (One) Line Electrical Engineering Diagrams	Y-32.1.1
6.	Electric Apparatus	Z-32.12
7.	Electric Power and Control	Z-32.3

Cost-conscious draftsmen will not only make use of standard symbols but will be on the alert to create additional symbols representing the delineation of repetitively used details associated with their particular business.

Conclusion: In order to take full advantage of any program for increasing drafting efficiency, the organization as a whole must be cost-conscious. Designers and draftsman must be encouraged to develop the habit of preplanning their work. After all, it is the man working daily at the drawing board who must put these savings into effect. It is he who must

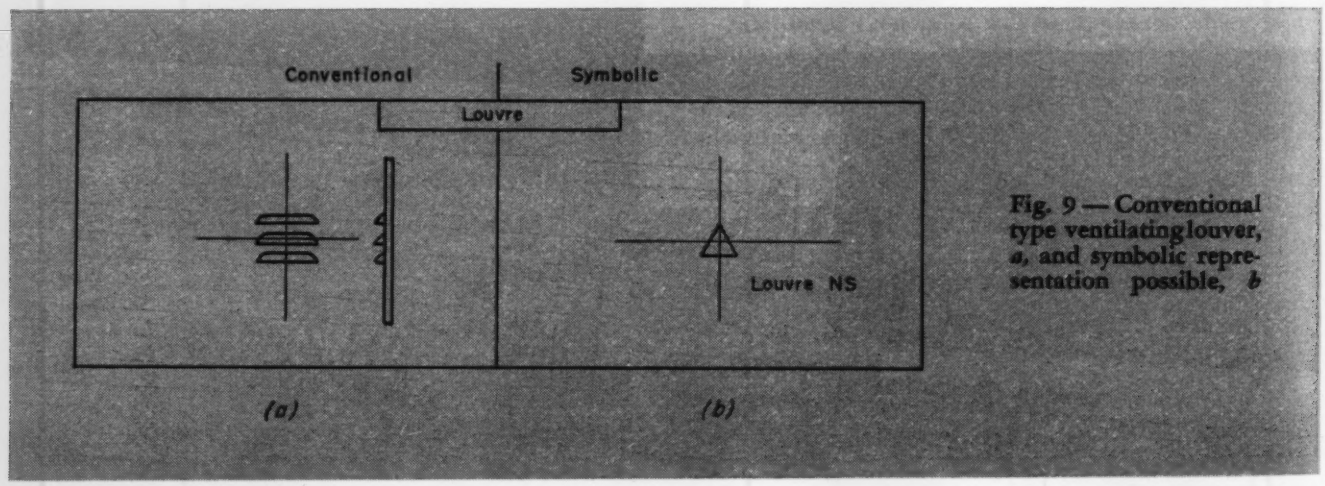


Fig. 9 — Conventional type ventilating louver, *a*, and symbolic representation possible, *b*

Any drafting organization can develop numerous applications for symbolic delineation by applying the principle to their repetitively used details.

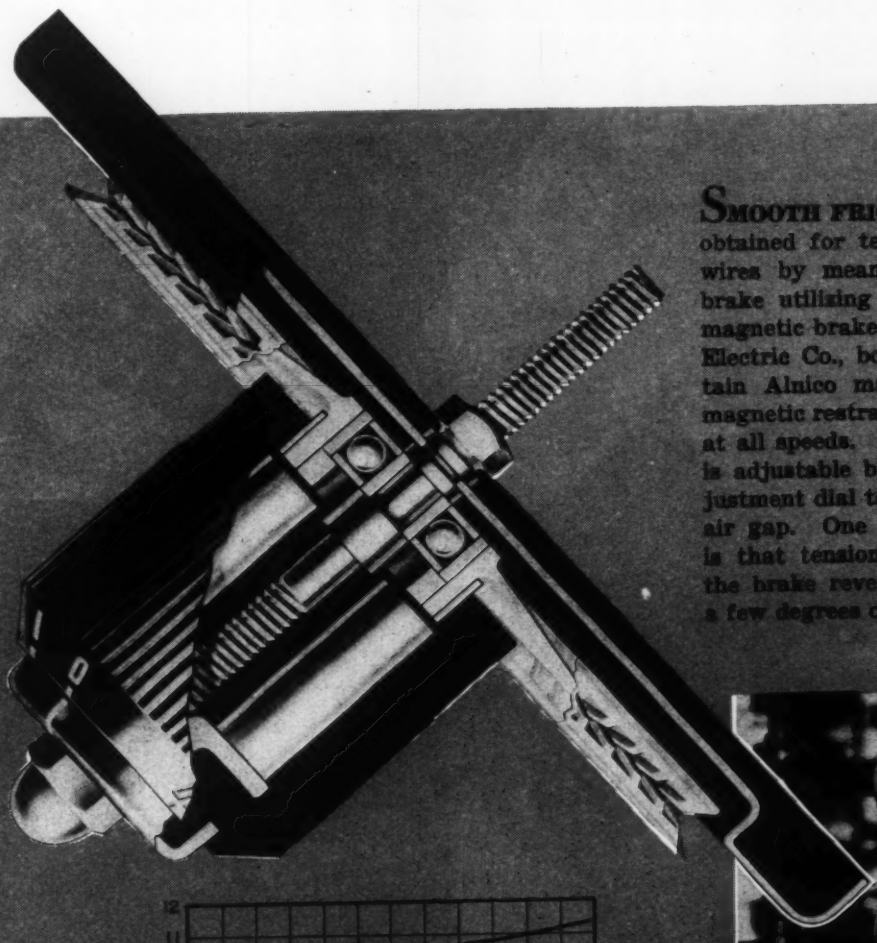
Generally speaking, any sign, mark or figure agreed upon and approved by all groups using a drawing can be substituted for the full delineation of the object. As an example, *Fig.* 9*a* shows the delineation of a louver used for ventilation which, if drawn symbolically as in *Fig.* 9*b*, provides sufficient information when those who are working with the drawing know what it purports to illustrate. Numerous examples of the application of signs and symbols will be found in any drafting system. The expansion of their use depends only upon the ingenuity and the cost-mindedness of the personnel of that organization.

Engineering Societies have co-operated with ASA committees in publishing standards on "Graphical Symbols for Drawing Use" covering almost every industry. Any drafting organization would do well to study the possibility of this "road map" type of drawing. Some of the ASA standards available covering eliminate the unnecessary line, the unnecessary view, or the unnecessary drawing. It is he who makes the simplified drawing or the elaborate one. By the very nature of his work, he has considerable license in spending the company's money and, therefore, has unlimited opportunity to effect savings by reducing drafting expenses, which, of course, in the end affect the selling price of any product.

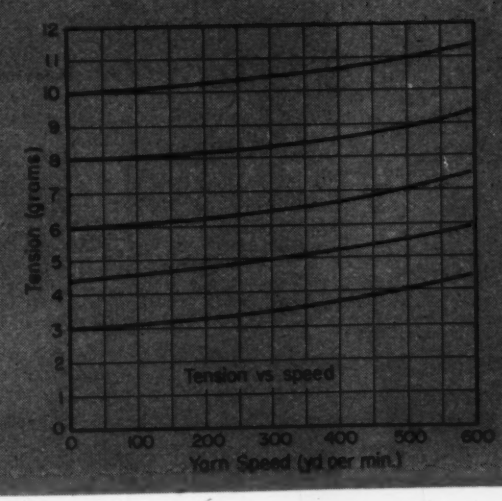
They Say...

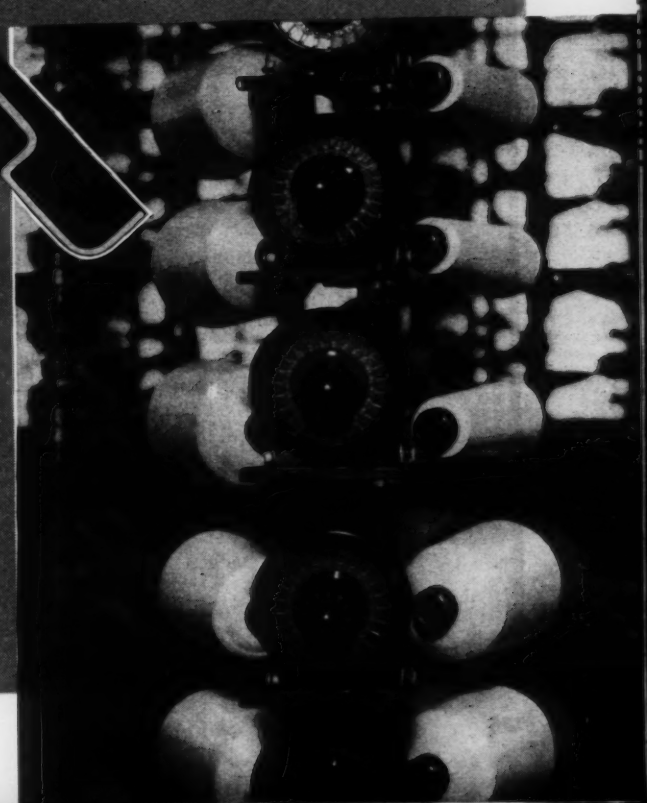
"Today over a third of the management of large industry in America is in the hands of engineers, over a third of mature engineering graduates now find their duties largely managerial in nature, and most engineers have important contacts with management. Management has recently become a profession into which the engineer now has preferred entree." — HARRY RUBEY, *professor and chairman, Department of Civil Engineering, University of Missouri.*

SCANNING the field for IDEAS



SMOOTH FRICTIONLESS TORQUE is obtained for tensioning of filaments or wires by means of a novel hysteresis brake utilizing magnetic drag. In this magnetic brake, designed by the General Electric Co., both rotor and stator contain Alnico magnets so mounted that magnetic restraint is essentially constant at all speeds. Magnetic drag or tension is adjustable by merely moving the adjustment dial to increase or decrease the air gap. One advantage of this design is that tension is held after stopping; the brake reverses direction of rotation a few degrees on coming to rest.

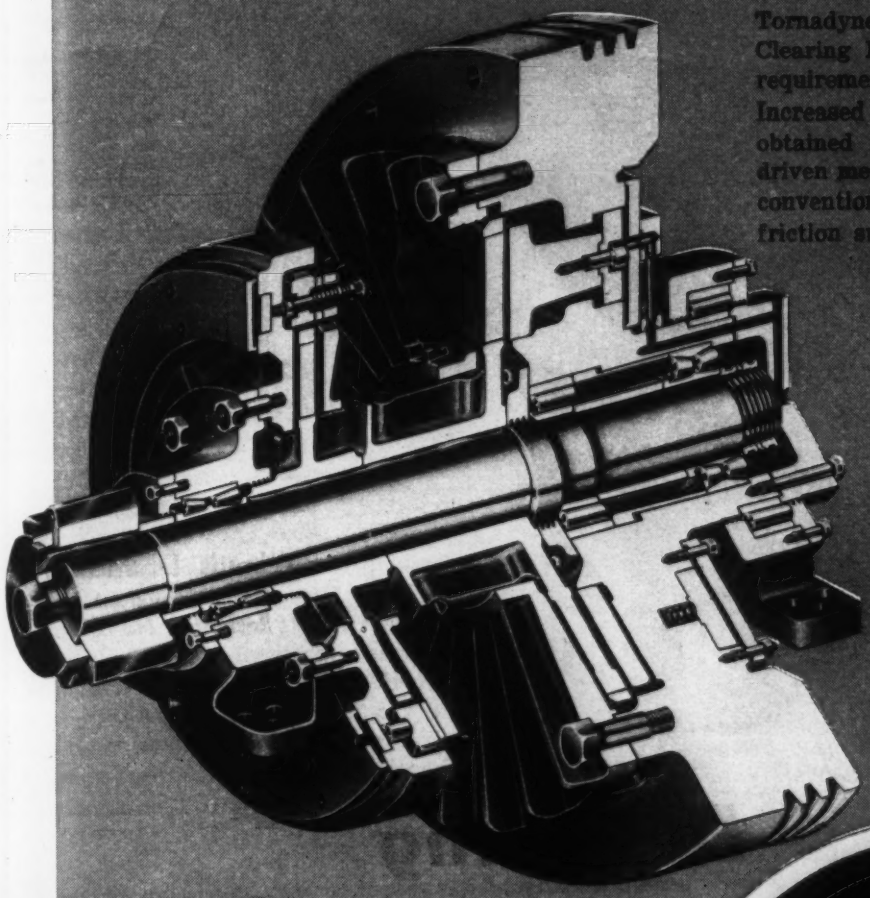




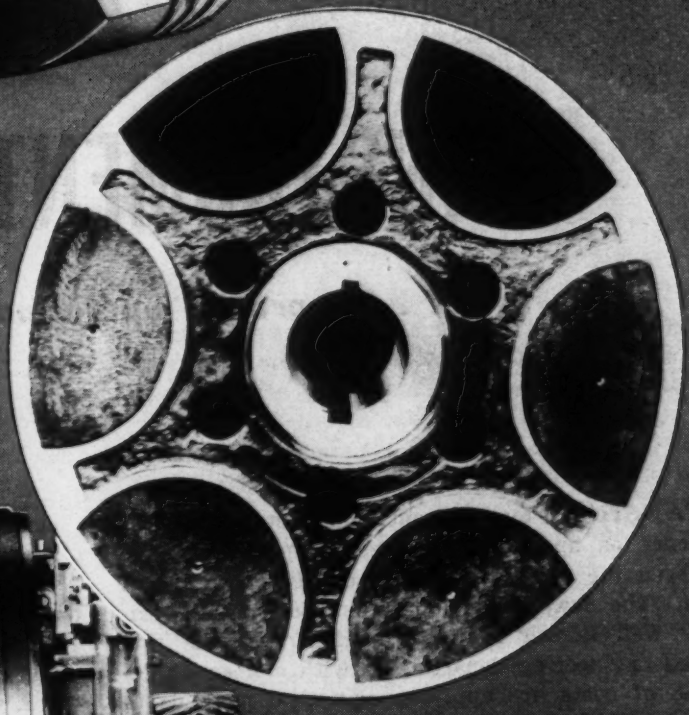
IDEAS

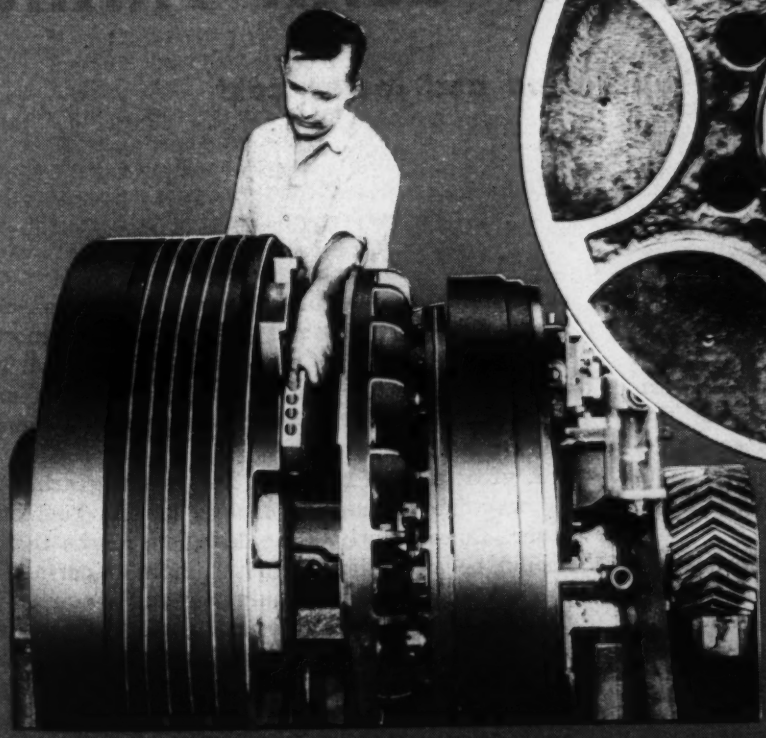
PACKAGED CIRCUITS simplify maintenance and improve reliability of complicated electronic equipment. Standardized plug-in units, developed by the National Bureau of Standards for use in electronic computers, are readily interconnected through special rack-mounted chassis to make up different types of electronic circuits varying in complexity and size. Misfunctioning packages can be rapidly detected and replaced, reducing down time to a minimum.

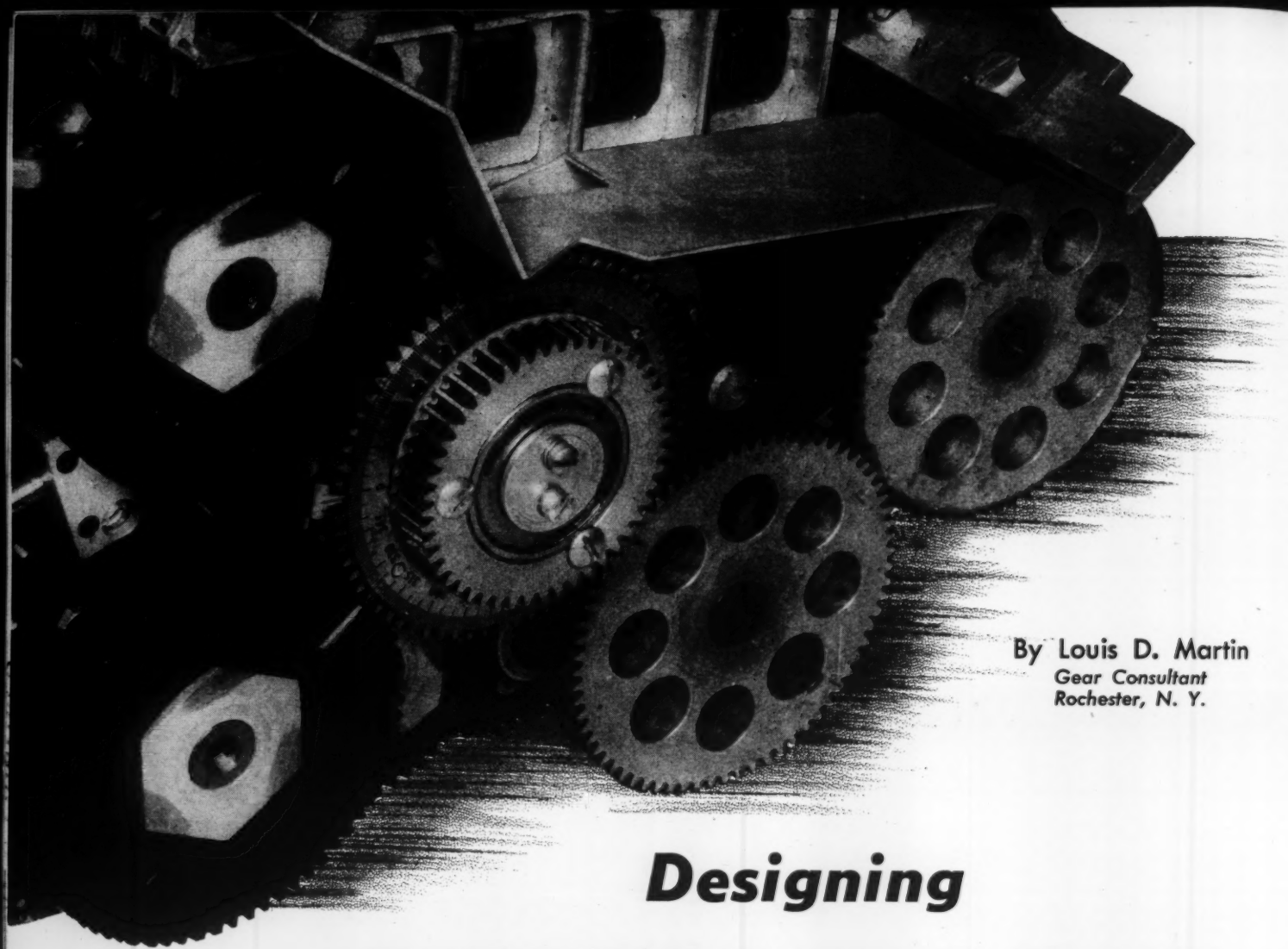
Designed around a single basic tube circuit, the units may be adapted to meet varying circuit stage requirements with only minor modifications. Etched circuitry and dip-soldering facilitate mass production and insure simple, foolproof construction. The basic package consists of an amplifier tube, a pulse transformer and several germanium diodes, the number varying to fit the application. A second type of package houses delay lines for connection between circuit stages. Most of the components in the individual packages have separate leads to the connector pins; flexibility in external connection is achieved and the testing of unplugged packages for faulty components is simplified. Heat generated during operation is dissipated by forced air cooling through holes in the sides and end of the package.



LOW-INERTIA STARTING DEMANDS in the Tornadyne clutch and brake unit designed by Clearing Machine Corp. cut initial drive power requirements to about half that usually needed. Increased response speed and decreased wear is obtained through a reduction in mass of the driven member of about 70 per cent compared to conventional units. Life and effectiveness of the friction surfaces are further extended by hemispherical segment design to place the maximum area at maximum radius. Replacement of the friction elements, which float in pockets in the mounting plate, is readily accomplished by hand by merely sliding back the cover plate. Extent of the lining wear is indicated by gage pins. Pneumatically operated, the unit employs air pressure for clutching action and spring return for braking. Packing and mechanical seals have been eliminated in the design by employing nylon air diaphragms and labyrinth oil seals.







By Louis D. Martin
Gear Consultant
Rochester, N. Y.

Designing
INSTRUMENT GEAR TRAINS

. . . for precise operation and lower cost

STATISTICAL quality control and statistical science as applied to engineering problems have been the subjects of much discussion in recent years. The laws of random distribution are generally well known to many engineers. Some farsighted engineering departments with a keen appreciation of costs are applying statistical methods to the allocation of tolerances and accept the law of random distribution as a useful tool.

However, one finds overconservatism in some designs. The temptation to overspecify is not resisted in many fields of engineering and in diverse mechanical devices. Utter lack of realism is evidenced in tolerance specifications for a set of components of a mechanical device intended to meet a given end requirement. This fault is particularly prevalent in the design of instrument gearing where needlessly close tolerances are often specified for some of the gears. Laws of probability are frequently ignored in this field. Study of random distribution of interrelated variables is evaded because of lack of understanding of probability laws or perhaps because of human inertia.

A great deal of precision instrument gearing finds its way into armament devices of one kind or another. Consequently, some designers reason that cost should be subordinated to the more important considerations of safety of equipment and personnel. This reasoning is sound as far as it goes. However, when the same end results can be obtained by intelligent application of tolerances and by use of laws of probability, it is poor engineering to call for closer tolerances than necessary.

The temptation to squeeze out that last half-

thousandth that is not required stems from the tendency to take the course of least resistance and call for the same tolerance in all the gears meshing together in a multistage gear train. Generally, equal tolerances are not necessary and can only lead to wasted manhours and, worse, to the procurement of hard-to-obtain precision equipment such as shaving machines, expensive shaving tools, grinding machines, and in some cases, lapping equipment.

A multistage gear train can be considered as a system of levers acting together. In precision applications, lost motion is usually a criterion of acceptance. The greater the leverage, the more critical the system becomes to lost motion.

A typical four-stage instrument gear train in current production is diagrammed in *Fig.* 1. This spur-gear reduction unit was chosen as the object of this discussion because of its simplicity. Other gear trains which may include worm and bevel gearing and have several driven members stemming from a common driving source would be more complicated and not serve as well for this discussion. But the reasoning to be outlined would be exactly the same. For a complicated gear train with several output sources originating from a common input, each branch would be considered as a separate system.

In the gear train shown in *Fig.* 1, control of lost motion within certain limits is desired. The 15-tooth pinion at 5 is the first driving gear and the 44-tooth gear at 1 is the last driven gear. If resistance to motion is applied to the 44-tooth gear, the 15-tooth driving pinion will have to turn through a certain arc before all lost motion is taken up and the last driven gear starts to rotate.

Maximum permissible lost motion in the gear train is specified in the following manner: When pinion 5 is rotated in a clockwise direction until gear 1 just starts to turn, and then is reversed in a counterclockwise direction, there shall be not more than 0.65 revolution of free movement of pinion 5 before gear 1 starts to turn.

To calculate the lost motion in a gear train, calculation of the backlash at each point of mesh is necessary. There are many ramifications to backlash. The American Gear Manufacturer's Association's gear nomenclature defines it as the amount by which a tooth space exceeds the tooth thickness of the engaging gear tooth. This definition is obviously an academic concept because many other factors are involved. Actually, backlash in involute gear teeth is a function of the difference between the tight contact center distance (no backlash) and the operating center distance. It can be expressed as follows (see Nomenclature):

$$B = 2(\Delta C) \tan \phi \quad \ldots\ldots (1)$$

Since backlash is affected by changes in center distance, all of the factors contributing to a center-distance change affect backlash:

1. Size of gear (testing diameter at high point of run-out)
2. Runout of testing diameter with axis of rotation
3. Center distance of gear mountings (plates or castings)
4. Clearance between journals and bearings

The change in center distance, ΔC, can be calculated by the following equation which takes into account the factors mentioned above:

$$\Delta C = C + 0.5\ (D_{bp} - D_{jp} + D_{bg} - D_{jg}) + e_p + e_g - 0.5\ (D_P + D_G) \quad \ldots\ldots (2)$$

Maximum backlash at each individual mesh is found by computation with tolerances that yield the greatest change in center distance. TABLE 1 shows the tolerances of the gear-train assembly, *Fig.* 1, that are necessary in the calculation of backlash.

These values are the drawing tolerances of the gear train according to the original specifications. All gears have the same tolerance, and the effect of ratio on lost motion has not been considered.

Nomenclature

B = Backlash
C = Center distance
D_{bp} = Bearing diameter for pinion
D_{jp} = Journal diameter for pinion
D_{bg} = Bearing diameter for gears
D_{jg} = Journal diameter for gears
D_G = Testing diameter of gear
D_P = Testing diameter of pinion
e_p = Runout of pinion (total indicator reading)
e_g = Runout of gear (total indicator reading)
R = Testing radius of gear or pinion
N = Number of gear or pinion teeth
ϕ = Pressure angle
θ = Arc of lost motion

Table 1—Original Example Specifications

Gear	Number of Teeth	Testing Diam. (in.)	Testing Tol. (in.)	Run-out (in.)	Bearing Diam. (in.)	Bearing Tol. (in.)	Journal Diam. (in.)	Journal Tol. (in.)	Center Distance (in.)	Center Tol. (in.)
A	44	0.440	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003	0.3101	±0.0006
B	17	0.179	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003		
C	57	0.570	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003	0.3751	±0.0006
D	17	0.179	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003		
E	89	0.890	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003	0.5306	±0.0006
F	16	0.170	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003		
G	82	0.820	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003	0.4911	±0.0006
H	15	0.161	−0.001	0.001	0.0625	+0.0003	0.0622	−0.0003		

Values derived from TABLE 1 can be substituted in Equations 1 and 2 to obtain the maximum backlash at the several points of mesh. Maximum change in center distance at mesh point *A-B* is, from Equation 2:

$$\Delta C = 0.3107 + 0.5\ (0.0628 - 0.0619 + 0.0628 - 0.0619), + 0.001 + 0.001 - 0.5\ (0.178 + 0.439)$$

$$= 0.0051\text{-inch}$$

With the calculated value of ΔC, Equation 1 gives

$$B_{AB} = 2(0.0051)(0.25862) = 0.0026$$

Backlash values at the other points of engagement—*C-D*, *E-F*, and *G-H*—are found in the same manner.

Lost motion due to backlash in any gear train is given by the following general equation:

$$\theta = \left\{\left[\left(\frac{B_{AB}}{R_B}\right)\frac{N_C}{N_D} + \frac{B_{CD}}{R_D}\right]\frac{N_E}{N_F} + \frac{B_{EF}}{R_F}\right\} \times \frac{N_G}{N_H} + \frac{B_{GH}}{R_H} \cdots \Big\} \frac{B_{GH}}{R_H} \cdots \Big\} \frac{N_X}{N_Y} + \frac{B_{XY}}{R_Y} \quad (3)$$

A sequence of gear meshes of a compound gear train is shown in *Fig.* 2, which bears the same nomenclature as Equation 3. *Fig.* 3 shows by letter designations how Equation 3 applies when idlers are used.

Substituting in Equation 3 the values derived from Equations 1 and 2 and from TABLE 1 gives for the lost motion

$$\theta = \left\{\left[\left(\frac{0.0026}{0.0895}\right)\frac{57}{17} + \frac{0.0026}{0.0895}\right]\frac{89}{16} + \frac{0.0026}{0.085}\right\}\frac{82}{15} + \frac{0.0026}{0.0805}$$

$$= 4.0525 \text{ radians}$$

$$= \frac{4.0525}{2\pi} = 0.64 \text{ revolution}$$

Since the allowable lost motion for the gear train shown in *Fig.* 1 was 0.65 revolution, tolerances given in TABLE 1 apparently satisfy the requirements. As already pointed out, specifying the same tolerance for runout and size of all gears—without concern for the effect of the ratio as shown by Equation 3—relegates all gears to the same common denominator of quality. This principle is obviously misapplied in this case because effort is wasted and overall quality of the product is not improved.

An excerpt from American Standard B6.11-1951 which covers the inspection of fine-pitch gears is presented in *Fig.* 4. In this standard, gears are divided in two classes—precision and commercial. Definitions of the two classes are clear and unmistakable. Quite evidently, the framers of this standard wished to prevent overspecification because the standard points out: "Commercial gears should always be given first preference because they are cheaper to produce. Experience has shown that they are suitable for most fine-pitch applications."

Another red-flag is placed under the precision gear group: "Precision gear should be avoided unless the functional requirements make their use imperative . . . Usually, precision gears cannot be produced by cutting alone." Subsequent refining operations are usually limited to shaving. Current prices for shaving tools for gears of the pitch used in the example given — 100 diametral pitch — cost approximately $550.00 and can be obtained at present from only one source. Shaving machines for gears of the size and pitch range found in the clock and meter industry are unobtainable, simply because the normal peacetime market cannot absorb a sufficient number of machines to warrant the cost of their development. Therefore, small gears with tiny pivots and holes, many of 18-8 stainless steel, must be shaved on relatively heavy and cumbersome machines. It must be remembered that the cost of tools and equipment used is reflected in the cost of the gears.

Now, the foregoing example might be re-examined. A few trial computations disclose that tolerances of different magnitudes, based upon the gear ratios, can be established to satisfy the design requirements. Results are shown in TABLE 2. Only one gear mesh, *A-B*, is slightly smaller than the preceding uniform tolerance of 0.001-inch and therefore falls in the precision class. The other three sets fall entirely within the commercial class.

The several factors involved in the backlash for

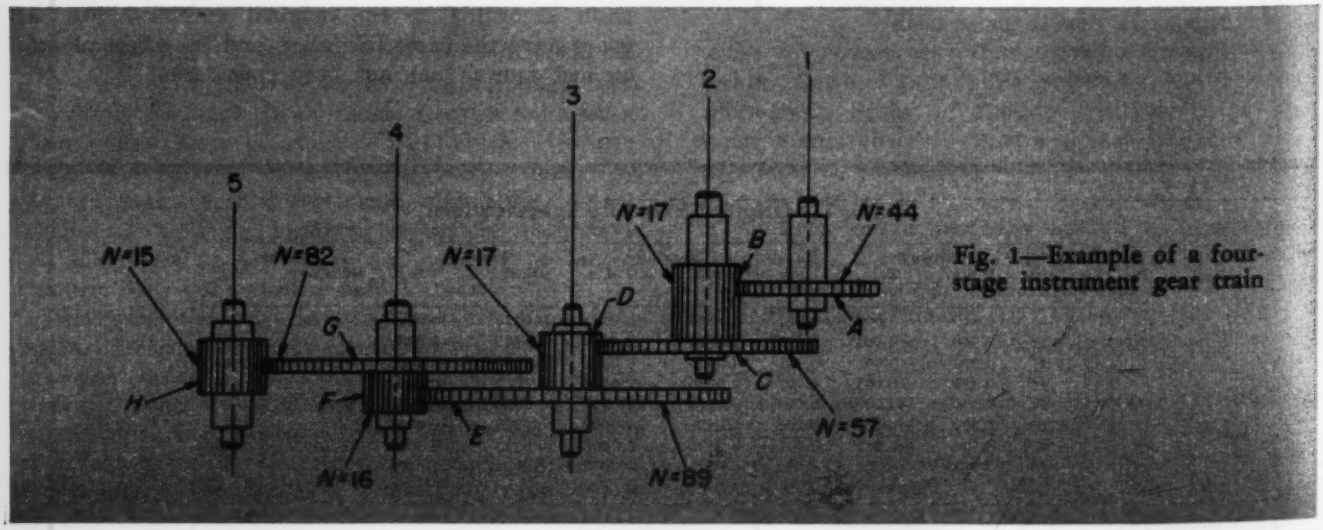


Fig. 1—Example of a four-stage instrument gear train

the gear train under discussion were given in TABLE 1. It has been shown that when tolerances of different magnitudes are allocated to the gears, compatible with the ratios, such tolerances can generally be greater than a uniform tolerance. Four major variables are involved in backlash:

1. Change in size, from a nominal, of the gear teeth. Resulting from tool wear, this factor can be governed regardless of whether a gear is of a precision or commercial quality simply by observation of tool wear and establishment of the optimum number of pieces cut per sharpening.
2. Total composite error (runout). This variable is not as easy to control because it is the result of the inherent limitations of the gear-cutting equipment. Particularly sensitive are the smaller of the fine-pitch gears.
3. Center distance variation.
4. Clearance between bore and bearing. This and the preceding variable can be controlled fairly easily.

There are a few other variables, of second and third order of importance, which might be considered. They are misalignment of axes, and influence of ratio effect (the phasing of certain teeth with other teeth in a train).

All of these variables respond to the laws of random distribution of errors. For the sake of simplicity, the effects of only the four listed variables will be considered.

This discussion so far has ingnored the influence of chance. The distribution curve of any four variables of a controlled manufacturing process shows that very seldom do the errors combine to give the worst effect.

The tolerances based on ratio in TABLE 2 were determined empirically, but were not influenced by any consideration of probabilities. When these gear tolerances are combined with those of the gear centers and with the play between bearing and shaft, the required lost-motion specification for the gear train of 0.65 revolution of pinion 5 is satisfied. In fact, lost motion is slightly less than required. The calcu-

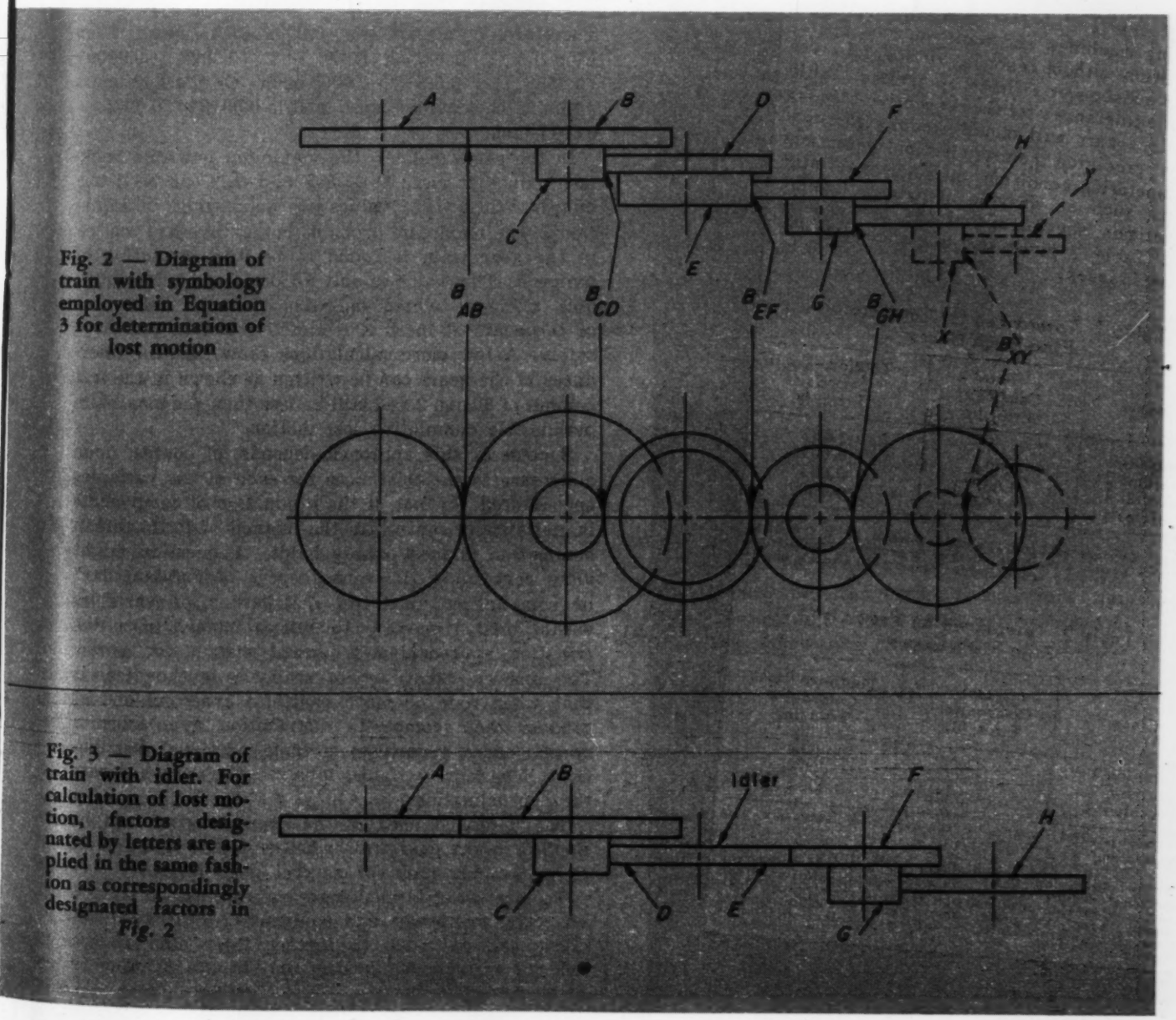


Fig. 2 — Diagram of train with symbology employed in Equation 3 for determination of lost motion

Fig. 3 — Diagram of train with idler. For calculation of lost motion, factors designated by letters are applied in the same fashion as correspondingly designated factors in Fig. 2

Table 2—Comparison of Tolerances

Mesh	Factor	Tolerances Original	Based on Ratio	Based on Ratio and Probability
A-B	Total composite error	0.001*	0.0007	**0.0015**
	Size variation	0.001	0.001	**0.001**
C-D	Total composite error	0.001	**0.0015**†	**0.002**
	Size variation	0.001	**0.001**	**0.002**
E-F	Total composite error	0.001	**0.002**	**0.002**
	Size variation	0.001	**0.002**	**0.002**
G-H	Total composite error	0.001	**0.002**	**0.002**
	Size variation	0.001	**0.002**	**0.002**
Lost Motion	0.65	0.64	0.64	0.64

*Light face designates precision gears.
†Bold face designates commercial gears.

Fig. 4—An excerpt from American Standard B6.11-1951 which points out the distinctions between precision and commercial class fine-pitch gears

16 Definition of Classes. Commerical gears can usually be produced on generally available gear-cutting machines and tools in good operating condition without resorting to special techniques or subsequent refining operations. Table 1 gives the tolerances for the respective classes.

Precision gears will usually require the best available precision gear-production equipment in good operating condition. Subsequent refining operations such as shaving, grinding, lapping and sometimes special techniques are usually required. Table 2 gives the tolerances for the respective classes.

Table 1 Tolerances for Commercial Fine-Pitch Gears

Class	Total Composite Error, In.	Tooth-to-Tooth Composite Error, In.
Commercial 1	0.006	0.002
Commercial 2	0.004	0.0015
Commercial 3	0.002	0.001
Commercial 4	0.0015	0.0007

Note: Commercial gears should always be given first preference because they are cheaper to produce. Experience has shown that they are suitable for most fine-pitch applications.

Table 2 Tolerances for Precision Fine-Pitch Gears

Class	Total Composite Error, In.	Tooth-to-Tooth Composite Error, In.
Precision 1	0.001	0.0004
Precision 2	0.0005	0.0003
Precision 3	0.00025*	0.0002

*This possibly would be the result of selection and segregation.

Note: Precision gears should be avoided unless the functional requirements make their use imperative. When used, due consideration must be given to their greater cost. Usually, precision gears cannot be produced by cutting alone. Subsequent refining operations or selection must be employed.

lations are based on the assumption that the diverse variables combine under the most favorable conditions all the time. If the variables are now subjected to the laws of random distribution of errors, much more realistic tolerances for the gears can be established.

Dimensions and tolerances for total composite error from the second tolerance column of TABLE 2 and those for center distance, bearings and journals given in TABLE 1 can be substituted in Equations 1, 2 and 3 to determine the maximum probable cumulative lost motion in the gear train. In these calculations the mean dimension is used so that equal bilateral tolerances can be employed. On this basis, normal distribution of errors about the mean can be anticipated and the maximum probable backlash can be obtained by a Pythagorean summation of all of the variables affecting backlash.

From Equation 2, with the adjusted dimensions from TABLES 1 and 2, ΔC for mesh *A-B* is found to be 0.0024-inch. The tolerances are now combined, not arithmetically, but as the square root of the sum of their squares. That is,

$$\pm \sqrt{(0.0006)^2+4(0.000075)^2+2(0.00035)^2+2(0.00025)^2}$$
$$= \pm \sqrt{0.0000007525} = \pm 0.0009 \text{ inch}$$

Therefore, $C = 0.0024 \pm 0.0009$ inch. Next, from Equation 1, backlash $BAB = 2\ (0.0024 \pm 0.0009)\ (0.25862) = 0.0012 \pm 0.0005$ inch. Or the maximum probable backlash at mesh *A-B* is 0.0012 + 0.0005 = 0.0017-inch.

In the same manner, the maximum probable backlash values at mesh *C-D*, *E-F* and *G-H* can be determined. When these values are substituted in Equation 3, the maximum probable cumulative lost motion in the gear train is found to be 0.48 revolution of pinion 5. This value is only 75 per cent of the allowable tolerance which indicates that the tolerances of the gears at mesh *A-B* and *C-D* can be increased safely. A few more calculations show that the tolerances in the gears can be written as shown in the last column of TABLE 2 and still be less than the maximum permissible cumulative lost motion.

Success of this approach depends, of course, upon adherence to the tolerances for each of the variables encountered. In fact, if the production of components is statistically controlled, the method of Pythagorean summation unquestionably holds. A question might arise concerning the consequences of "rectangular" or some other unnatural distribution of variables within their respective tolerances instead of a distribution approaching a normal distribution curve. The answer, according to statistics authorities, is that when four or more variables are combined at random their composite distribution approaches a normal curve, regardless of their individual distributions. The more variables involved, the more accurate the approximation.

The approach used in the example given can be applied to any gear train whether a simple spur unit or a complex train of several gear types.

To meet today's challenge, sights must be trained on costs, manpower and equipment. Statistical analysis can do much to further these aims in the field of instrument gearing and in other branches of mechanical science.

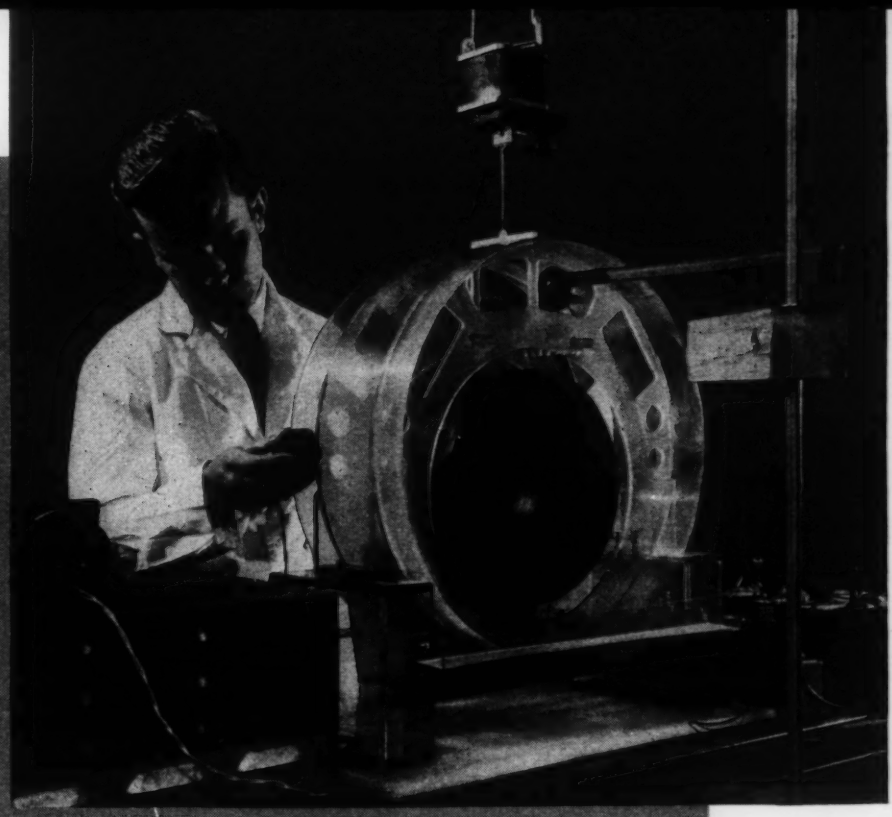


Fig. 1—Plastic model of a generator frame set up for vibration analysis

By G. O. Sankey
Research Laboratories
Westinghouse Electric Corp.
Pittsburgh, Pa.

Plastic Models for VIBRATION ANALYSIS

VIBRATION studies of complex structures can easily be made with inexpensive plastic models —an extension in the use of models from purely static tests involving loads and deflections to dynamic investigations of natural frequencies and modes of motion. This approach presents many advantages in studying systems for which mathematical computation, even by a calculating machine, is complex and uncertain.

In this method, the model is constructed geometrically similar to the prototype structure and usually to some greatly reduced scale, *Fig.* 1. Alternating forces are applied to the model over the frequency range of interest with an electromagnetic driver. A typical resonance curve results, readily interpreted for the prototype by consideration of the differences between mechanical properties of model and prototype materials. Vibration peaks for the structure can then be adjusted safely away from known excitation frequencies which for example, are usually 60 and 120 cycles per second for the structure shown in *Fig.* 1.

Plastic models are inexpensive to construct, light in weight, and easily modified to include proposed design changes. Mechanical properties of the material

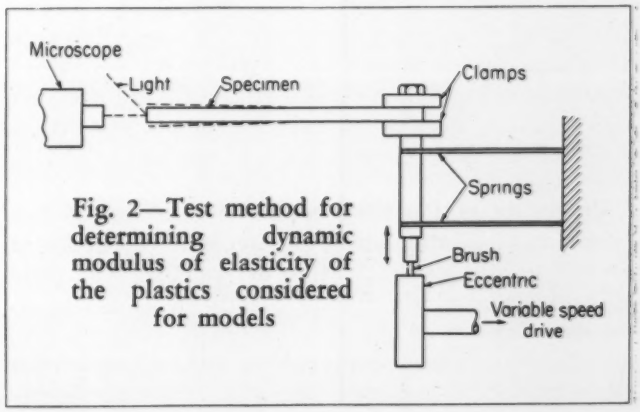


Fig. 2—Test method for determining dynamic modulus of elasticity of the plastics considered for models

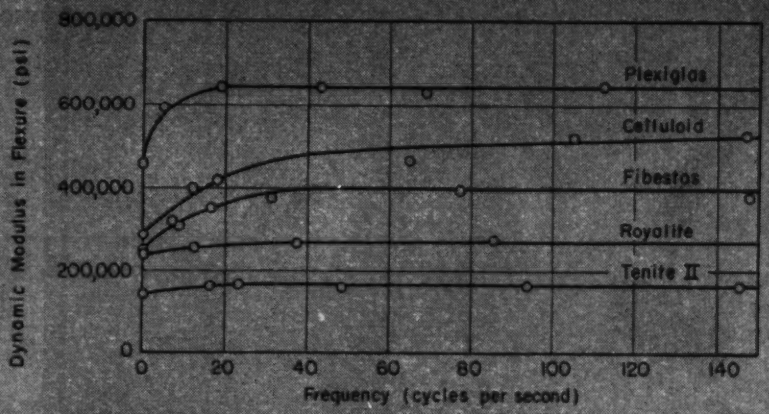


Fig. 3 — Dynamic modulus values in flexure for typical plastics

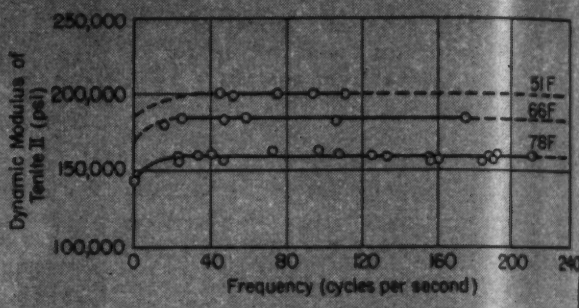


Fig. 4—Variation with temperature and frequency of dynamic modulus for one plastic

are such that the frequencies of interest are low—where vibration excitation and measurement are convenient—even for small-size models of large steel structures. Proper interpretation of test results, however, depends on properties of the plastics. Since these properties are influenced by temperature and vibration frequency, they must be carefully evaluated over the range of conditions encountered during actual model tests.

Dynamic Similitude: Conversion of plastic model response data to prototype results is readily handled with the governing model law for geometrically similar elastic structures:

$$K_n = \frac{1}{K_L}\sqrt{\frac{K_E}{K\rho}}$$

or

$$\omega_p = \left(K_L\sqrt{\frac{K\rho}{K_E}}\right)\omega_m$$

where K_n = ratio of model to prototype critical frequency for similar modes of vibration; K_E = ratio of model to prototype dynamic modulus of elasticity; K_ρ = ratio of model to prototype material density; K_L = model to prototype scale ratio; and ω_m and ω_p = model and and prototype critical frequency, respectively.

Thus, prototype critical frequencies are readily determined from the model scale and the differences in the mechanical properties of the model and prototype materials. Higher natural frequency of the model due to scaling may be reconciled by choice of a model material that has a low modulus-to-density ratio.

Properties of Plastics: In the development of this approach at Westinghouse, the dynamic properties of several plastic materials were determined. The ratio of modulus of elasticity and density, E/ρ, and internal damping are of interest. Effects of vibration frequency temperature, and humidity on these properties were initially considered important. As previously indicated, ratio E/ρ determines the scale of the model. Internal damping is of concern because a high value for this quantity may distort the vibration modes and make excitation difficult.

Samples of the plastics in TABLE 1 were tested. From beam test specimens supported as cantilever beams, *Fig.* 2, first and second-mode natural frequencies were determined. Dynamic modulus of elasticity values were calculated with the cantilever-beam frequency equation. Internal material-damping values were also obtained from the width of the resonance curve between half-peak amplitude values, and from logarithmic decrements recorded on a magnetic oscillograph. Values of dynamic modulus at 77 F appear in *Fig.* 3 and of internal material damping in TABLE 1. Values of dynamic modulus vary with vibration frequency, and the average value of internal damping of about 0.25 indicates resonant amplitude buildups of about 12 times.

For actual model construction, a plastic with an extremely low modulus-density ratio, Tenite II, was selected. At this point several cantilever-beam test specimens were taken directly from the model supply to permit accurate determination of:

1. Dynamic material modulus values at three temperatures
2. Modulus variations with several months aging
3. Modulus variations with changing humidity
4. Modulus variations with various specimen width-thickness ratios

Results of these tests* indicate that only modulus variations with frequency and room temperature fluctuations are of importance.

Modulus values as a function of frequency at three temperatures, *Fig.* 4, probably, would not hold for another lot of the same material; however, few additional tests would be required to obtain accurate values of dynamic modulus.

Generator Frame Analysis: To confirm the validity of the method, a plastic model was manufactured

*G. O. Sankey—"Plastic Models for Vibration Analysis," SESA paper, December, 1952, New York.

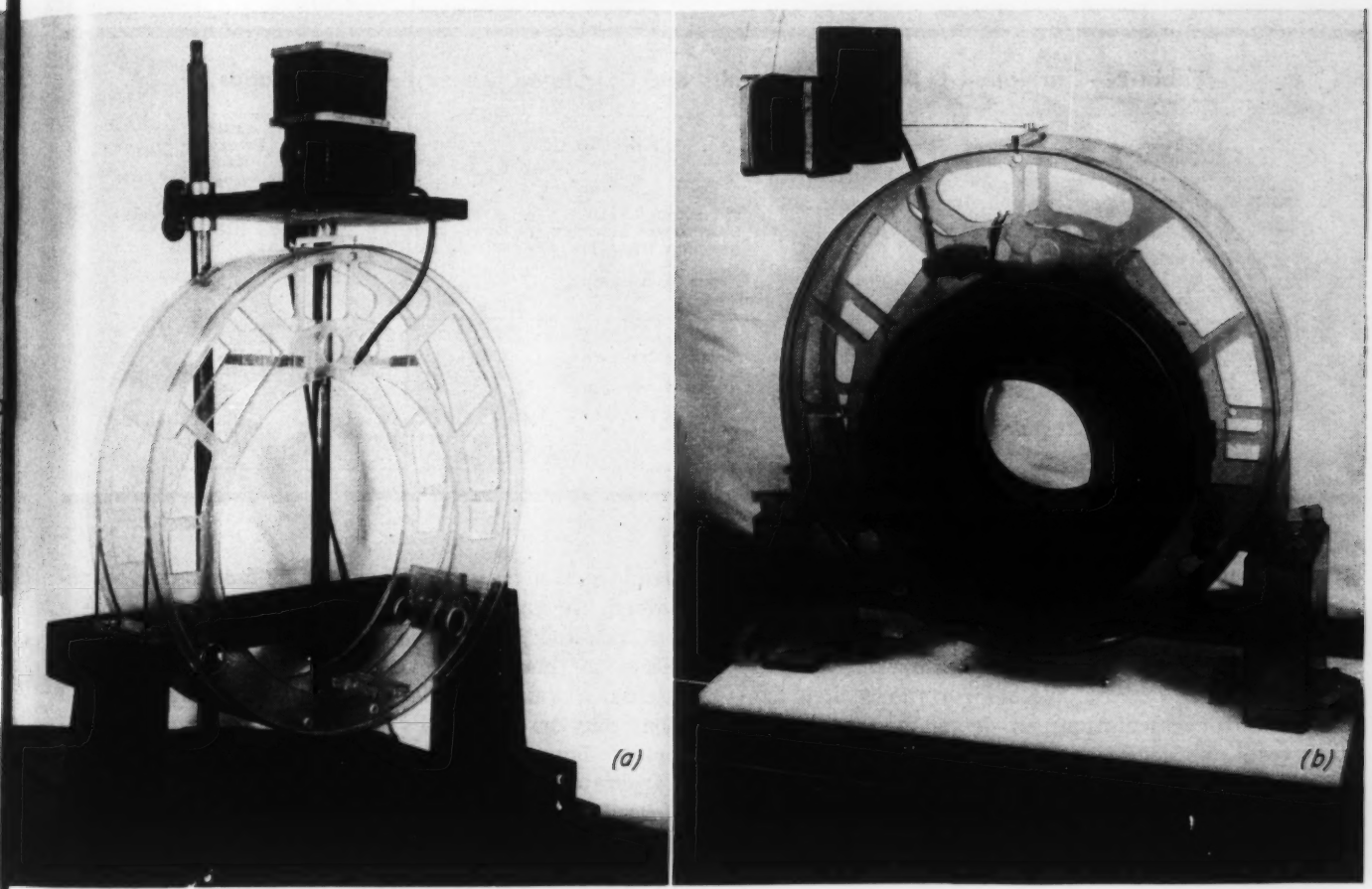


Fig. 5—Setup for vertical excitation on rigid wood base, *a*. Horizontal excitation setup, *b*, also shows plastic-spring mounted core and flexible plastic base

of a full-size steel model of a turbine-generator frame section that had been previously tested for its vibration response characteristics. The use of a ⅛ scale produced a model that was dimensionally suitable and convenient for laboratory tests. The fundamental frame assembly is shown in *Fig.* 5*a*, while *Fig.* 5*b* includes the model core which is supported on four plastic springs. In the prototype, the core was a rigid body compared to the frame; hence, any material could be used for the model core if the proper rigidity—mass relationship is retained. Actually, wood was used, with lead slugs inserted to produce the correct frame-to-core mass ratio. A plastic foundation, which is essentially a scaled model of the prototype, is also shown in *Fig.* 5*b*.

The model was excited by means of a velocity type pickup with the pickup coil mechanically coupled to the model assembly. From an oscillator source, a fixed current was passed through the coil over the frequency range of interest. A crystal type phonograph pickup was held against the model and its signal metered for amplitude of model vibration over the frequency range. A typical resulting resonance curve is shown in *Fig.* 6.

Resonant frequencies of the model are shown in

Fig. 6 — Typical resonance curve for vertical excitation

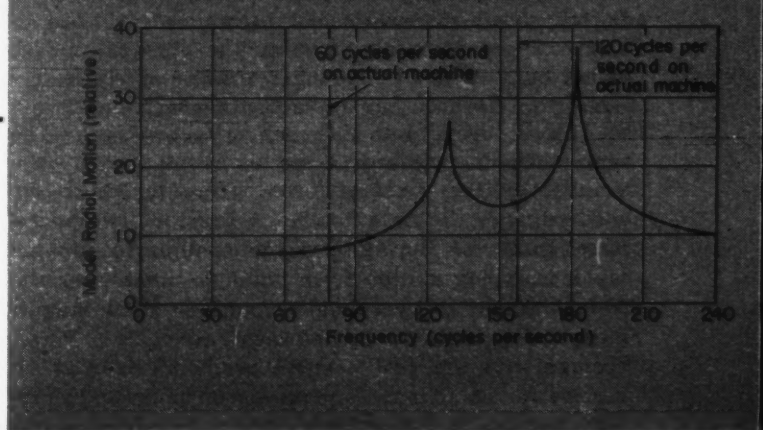


Table 1—Damping Characteristics of Plastics

Plastic	Type	Log Decrement
Tenite II (233MS)	Cellulose acetate butyrate	0.16-0.22
Plexiglas	Methyl methacrylate	0.16-0.24
Celluloid	Cellulose nitrate	0.28-0.35
Royalite	Rubberized phenolic	0.06-0.09
Fibestos	Cellulose acetate	0.24-0.25

Table 2—Correlation Between Test Results and Calculated Critical Frequency Ratios

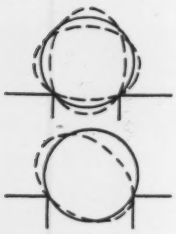
Mode of Vibration	Type of Excitation	Foundation Stiffness	Assembly Details	Actual Critical Frequency (cps) Model	Actual Critical Frequency (cps) Prototype	Critical Frequency Ratio
	Vertical	Flexible	Outer frame assembly (no core)	123.5	78.5	1.57
	Vertical	Rigid	Outer frame assembly (no core)	142	95	1.50
	Vertical	Rigid	Assembly with core	138	90	1.54
				183	117	1.56
	Vertical	Flexible	Assembly with core	114.5	75	1.53
	Lateral	Rigid	Assembly with core	117	81	1.45
				144	92.5	1.56
	Lateral	Flexible	Assembly with core	87.5	61.6	1.42
					Mean critical frequency ratio	1.52
					Calculated critical frequency ratio	1.52

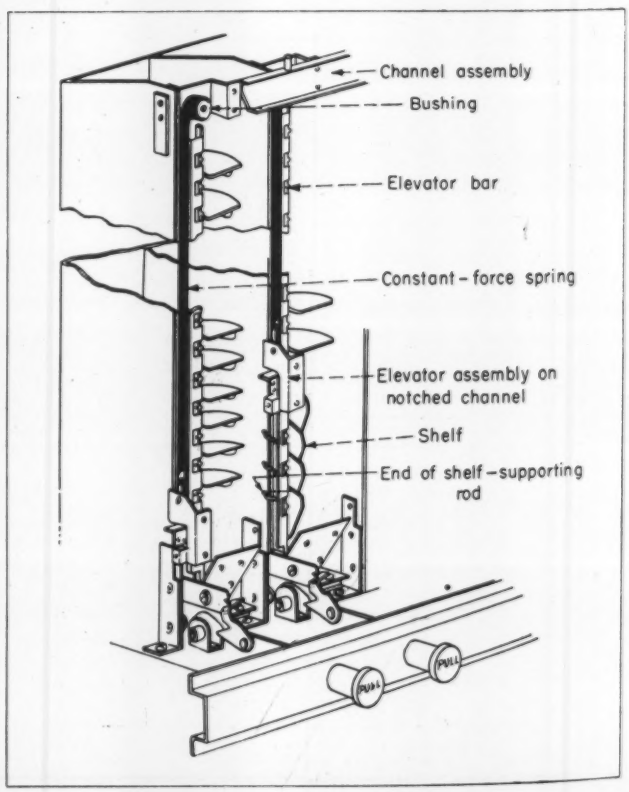
TABLE 2 along with actual prototype resonant frequencies for similar modes of vibration. Ratio of these two frequencies for each set of conditions is shown in the last column, and should be compared with the calculated value of 1.52. Values for the various factors used for calculation, as determined from previous tests and conditions, are: $K_n = 1/8$, $K_E = (1.6 \times 10^5)/(30 \times 10^6)$, and $K_\rho = 0.0425/0.283$. Maximum deviation from the calculated value is 7 per cent. Actually, prototype critical frequencies accurate to within an average of 5 per cent have been obtained by this method. The type of vibration for each critical frequency may also be determined.

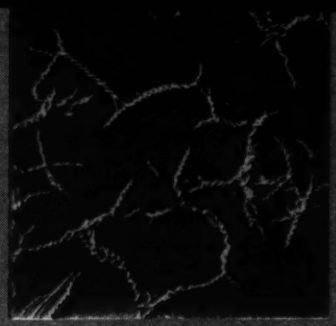
Thermoplastics have several advantages as a dynamic model material. Firm model joints can be obtained through ordinary cementing methods without introducing additional damping in the structure. Ease of machining and cementing thermoplastics yields a relatively inexpensive, lightweight model that may be excited by existing methods and equipment. Thus, models may be altered quickly to incorporate new design changes; for instance, the model described above was altered to determine the dynamic response of two additional designs.

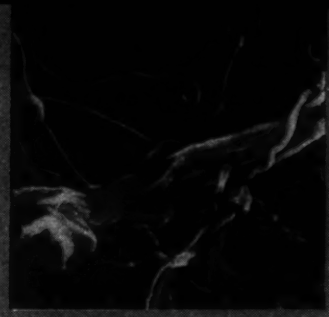
Plastic models should be useful in vibration studies of many other forms, particulary in the design of such structures as ships, airframes and machine rotors, where vibration characteristics are important.

Vending Machine Mechanism Simplified

REPLACING a more complicated system of cams and levers, the unit design shown here was developed by Rowe Manufacturing Co. for candy vending machines. Shelves are raised to the horizontal position by pulling of the elevator assembly down to the bottom notch, or to any intermediate notch. As the elevator assembly passes each notch, a tab cams the end of the shelf-supporting rod behind the return flange of the channel, thus lifting the shelf for loading. The elevator assembly is held at a given notch by a spring-loaded pawl. The pawl is released and the toothed elevator bar is cammed forward to secure the elevator assembly as the plunger knob is pulled out. When the plunger returns after the release, the elevator bar retracts, the shelf falls, and the candy drops into the delivery chute. At the same time, the elevator assembly is snapped up the channel by the constant-force spring to where the pawl engages the next notch. A constant two-pound force from the spring is large enough to provide rapid, snapping motion from notch to notch over the 26-inch range and yet small enough to allow simple, inexpensive parts in the elevator assembly. Power springs with inherent positive gradients exerted excessive forces at maximum extension in order to provide the smallest acceptable force at the first notch.







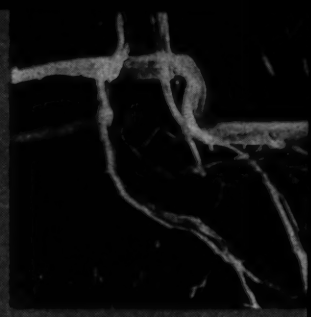


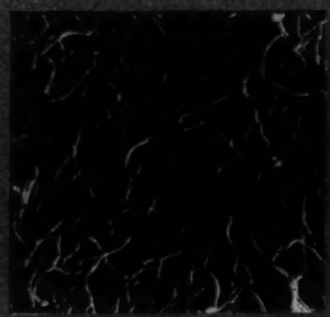
Fig. 1 — Fibrous structure of lubricating greases, obtained by metal-shadowing techniques with an electron microscope

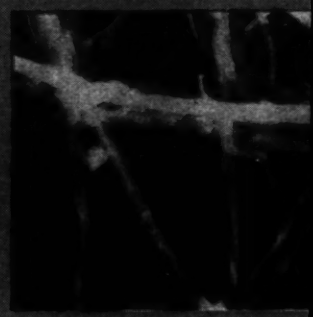
Photos, courtesy California Research Corp.

a—Calcium-base grease

b—Long-fiber sodium-base grease

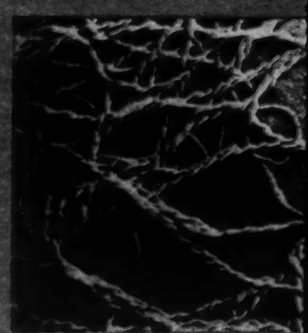
c — Medium-fiber sodium-base grease





d — Short-fiber sodium-base grease

e—Barium-base grease



f—Lithium-base grease

Basic Properties of LUBRICATING GREASES

By C. J. Boner

Chief Research Chemist
Battenfeld Grease & Oil Corp.
Kansas City, Mo.

SPECIFYING greases by performance rather than by composition is a more basic approach to adequate grease lubrication. In recent years, the Armed Forces have adopted this altered view toward grease specifications, and this same attitude might well be more generally adopted by industry.

Since a wide variety of greases is available, including new formulations now in the semicommercial stage, this revised attitude frees the designer from the arbitrary specification of a particular type of grease. A deeper understanding of the fundamental compositions and capabilities of lubricating greases is necessary, however, if intelligent recommendations for use are to be drawn up. This article will review these basic factors, outline some of the broad service considerations, and point out new areas for future consideration.

Basic Grease Components: Lubricating greases consist of lubricating fluids thickened with gelling agents. The lubricating fluids in a great majority of cases are mineral oils which may vary in viscosity from those only slightly heavier than watch oil to those which have a high viscosity. The higher the viscosity of the oil employed, the greater the internal friction as one particle moves over another. The lower the viscosity of the oil, the smaller the factor of safety for preventing metal-to-metal contact. Most oils employed in lubricating greases, therefore, are a compromise and are usually similar in viscosity to an SAE 20 or 30 motor oil. Several types of synthetic lubricating fluids are employed to a limited extent in lubricating greases for specialized applications.

Soaps, which are combinations of metals and fatty acids, are the most common thickening agents employed for the production of lubricating grease. Soaps can be made from practically any metal, but only a limited number of such compounds produce satisfac-

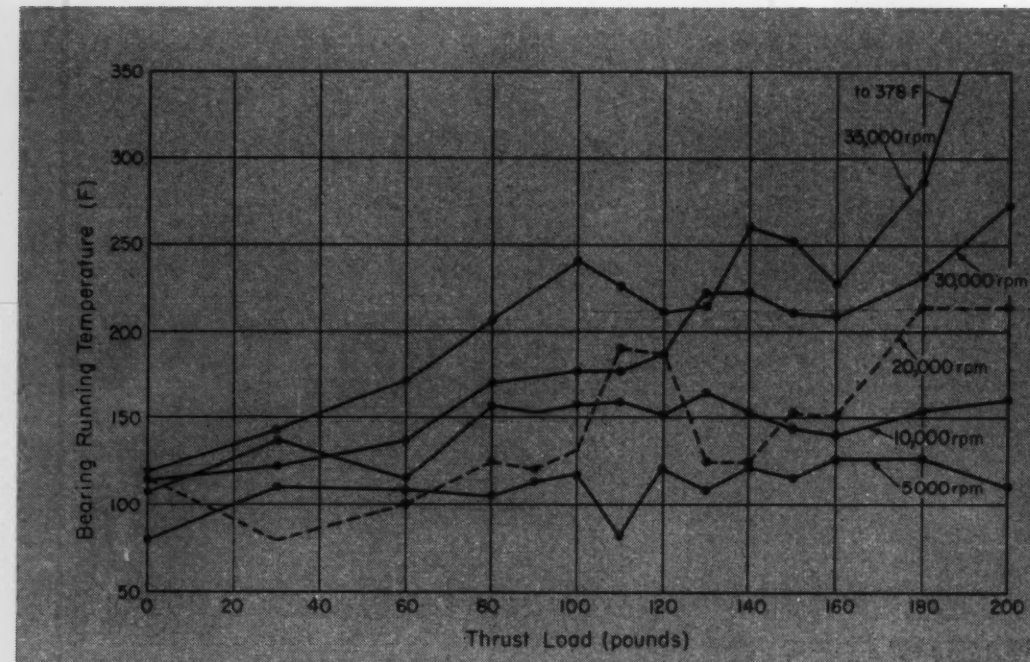


Fig. 2—Effect of load on bearing running temperature at various speeds, based on tests by The Texas Co. with NA-G-15a grease and super-precision bearings

tory lubricating greases. The first two types of soaps so used were calcium (lime) and sodium (soda) soaps, which still predominate as bases for lubricating greases. In addition, soaps of other metals are now employed, some of them because they contribute characteristics to the lubricating greases which are unobtainable with the calcium and sodium soaps. These others include aluminum, barium, lithium, and strontium soaps. Some lead and zinc soaps are also used in formulating lubricating greases but they function for purposes other than thickening agents.

Soap structures, as revealed by an electron microscope, *Fig.* 1, are fibrous in nature. Because of this fibrous structure, small amounts of solids (thickening agents), averaging 7 to 20 per cent of the total weight of the lubricating grease can immobilize large amounts of lubricating fluids. Width of such fibers is from 0.1 to 1 micron. Length, for buttery type lubricating greases ranges from 0.2 to 20 microns, and up to 500 microns for a fibrous type.

Several nonsoap thickening agents are also employed for contributing a grease-like nature to lubricating fluids. These materials actually give a gel-like structure similar to that obtained by the use of soaps. Some of these thickeners are clay-base products, the clay having been reacted with organic compounds to contribute water resistance. Another bodying agent is silica, employed in particle size ranging from 1 to 3 microns. Because of this very small particle size, such silica is not abrasive. Certain types of carbon black are also used to densify lubricating fluids and thus form lubricating greases.

In addition to true thickening agents, fillers are sometimes used in lubricating greases. These are materials which change the oil to a semisolid by their bulk alone and in most applications are not particularly desirable.

Much attention is now focused on lubricating greases having small amounts of additives, which are used to modify or enhance particular characteristics.

Table 1—Characteristics of Industrial Lubricating Greases

Type	Texture	Maximum Recommended Temperature (F)	Water Resistance	Resistance to Working	Service Life
Soap Base					
Aluminum soap	Smooth and stringy	175	Fair	Poor	Short
Barium soap	Buttery or fibrous	350	Good	Good	Moderate
Calcium soap	Smooth and buttery	175	Good	Good	Moderate
Lithium soap	Smooth and buttery	300*	Fair	Fair to good	Moderate to long
Sodium soap	Buttery or fibrous	250	Poor	Fair to good	Moderate to long
Strontium soap	Buttery or fibrous	400	Good	Good	Moderate to long
Nonsoap Base					
Organic modified bentonite	Smooth	250	Good	Fair	Moderate
Silica gel	Smooth	250	Poor	Poor	Moderate
Carbon black	Smooth	250	Good	Good	Moderate to long
Copper phthalocyanine	Smooth	400*	Good	Good	Long

*Have good low-temperature properties.

Thus, where the lubricant is to be employed for a long period without renewal, an oxidation inhibitor is included. For heavily loaded bearings an extreme-pressure additive may be employed.

Temperature Limitations: While most machine requirements call for lubrication in operating and ambient temperatures below 100 F, many pieces of equipment must operate at temperatures much outside this range. For example, electric motors with silicone insulation can be operated at 300 F. The limiting factor in operation at this temperature, which is economical from an efficiency standpoint, is to secure a lubricating grease which will not deteriorate over a considerable period. This illustration, of course, is somewhat extreme, but operating temperatures outside the normal range may often be encountered. High-temperature limitations for use of various lubricating greases are noted in TABLES 1 and 2.

Low-temperature range of lubricating greases is determined by the stiffness or inability to move at such temperatures. Fluid in a lubricating grease can freeze just as can other liquids. Long before crystallization of the liquid occurs it may become so viscous that it will be heavier than thick molasses. This objection can normally be overcome by proper choice of fluids as well as soaps.

Limitation on the high side of the temperature range is the deterioration of the lubricating grease, due either to volatilization of some constituent or to oxidation which will generally accelerate once it starts. By proper choice of a lubricating fluid and addition of oxidation inhibitors, deterioration can usually be curtailed at most desired operating temperatures.

Typical of how a soap-oil system changes with temperature is a calcium-soap and mineral-oil grease. A solubilizing agent is employed in most cases, consisting of perhaps one per cent of water. If this water is driven off in service, the soap separates from the oil and the plastic nature of the lubricating grease is lost. Hence, temperature is limited to 175 F for this type of lubricating grease.

Action of heat on lubricating greases consisting of oil thickened with aluminum soaps is different. When excessive heat is applied, the mass loses its plasticity and assumes a rubbery quality. The mass may, therefore, pull away from the metal, and certainly will not flow or be drawn into the parts requiring lubrication.

A factor of safety has been figured in all of the temperature limitations shown in the tables. For example, sodium-base lubricating greases may gradually soften as the temperature is increased, until a point is

Photo, courtesy Anti-Friction Bearing Manufacturers Association Inc.

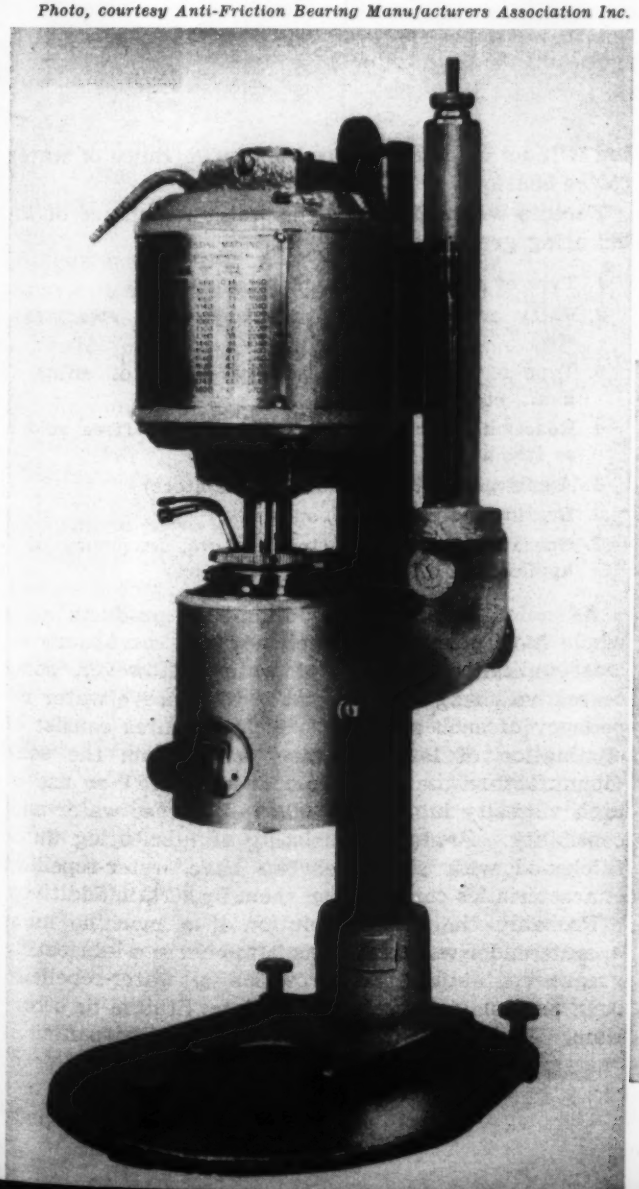
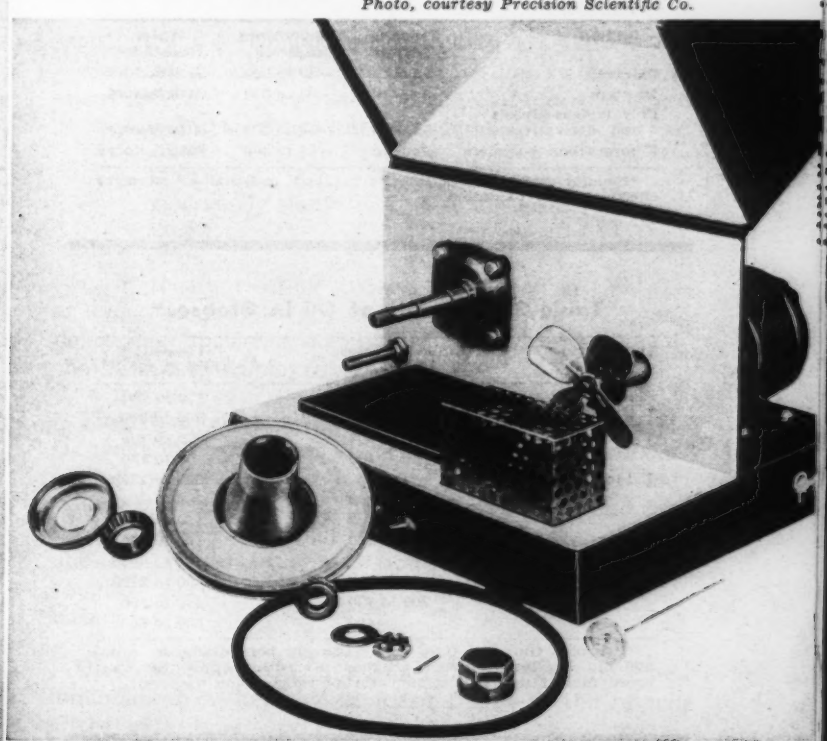


Fig. 3—Left—BEC grease testing machine which indicates changes in grease structure and also running torque

Fig. 4—Below—CRC wheel-bearing tester, in which bearings can be tested at temperatures up to 220 F at speeds equivalent to 40 to 60 mph

Photo, courtesy Precision Scientific Co.



reached where they become semifluid. This point will normally be above 300 F. Similarly, the soap-oil combination of lithium-base greases retains its plasticity up to about 360 F, above which it becomes fluid. Barium and strontium-base lubricating greases do not become fluid even at 400 F; hence their limitations are in the main determined by the oxidation stability of the oil component. In determining operating temperature, consideration should also be given to the effects of bearing load and speed, *Fig.* 2.

Water Resistance: While in most locations the lubricating grease in a bearing is not subjected to action of water, it is sometimes encountered. With the exception of sodium-base lubricating grease and lubricants in which fine silica is the thickening agent, lubricating greases resist the action of water fairly well (see TABLE 1). Modification of formulations of either of these products susceptible to moisture may improve the water resistance. In any event, a variety of lubricating greases are available which will withstand the washing effect of water.

If water does enter a bearing which is grease lubricated, it will be worked into the lubricant, and if this can be done without destroying the grease structure, no harm may result. In this case the lubricating grease is said to have good water-absorption characteristics.

Water repellency or water-absorption characteristics determine why some lubricants can be used in the presence of water and others cannot. Water repellency probably determines whether a lubricating grease will resist wash-off and also whether the excess lubricating grease adhering to the outside of the bearing will act as a seal to prevent the entrance of water to the bearing.

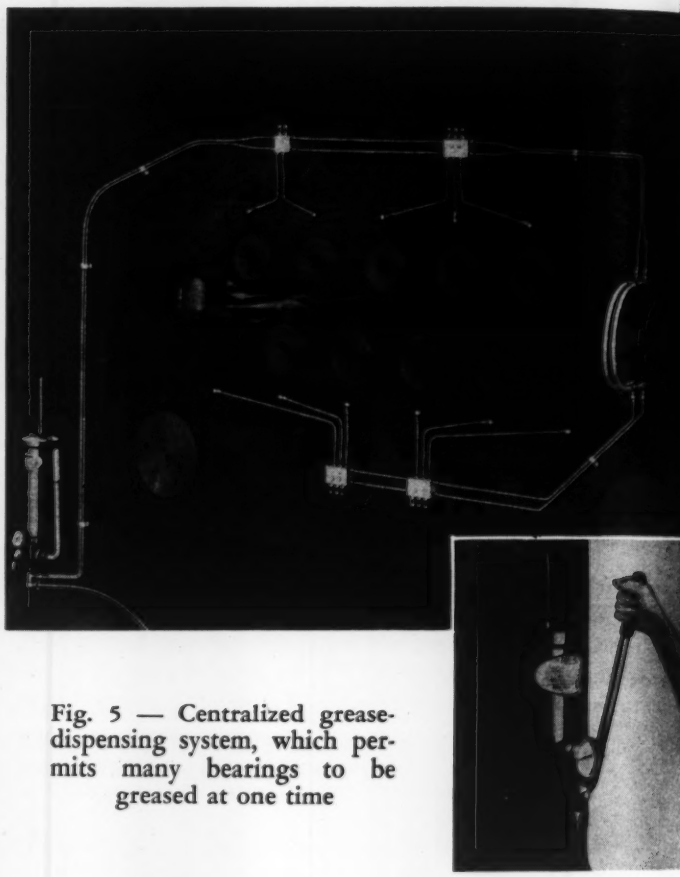


Fig. 5 — Centralized grease-dispensing system, which permits many bearings to be greased at one time

Factors which influence the water resistance of lubricating greases are:[1]

1. Type of soap (calcium, sodium, etc.)
2. Fatty acid component of soap (oleate, stearate, etc.)
3. Type of mineral oil (viscosity, degree of refinement, etc.)
4. Reaction of finished lubricating grease (free acid or free alkali)
5. Additives (rust and oxidation inhibitors)
6. Bearing design (sealed, open, etc.)
7. Operating conditions (temperature, frequency of application of lubricating grease, etc.)

As noted in TABLE 1 sodium-base products as a whole have poor water repellency and can absorb almost unlimited amounts of water. However, some corrective changes can be made to improve water repellency of such products. Such measures consist of elimination of low-titer fatty acids from the soap (manufacture the soap from stearic acid) or use of high viscosity lubricating oils to decrease water susceptibility. Products consisting of lubricating fluids thickened with silica gel can have water-repellent characteristics conferred on them by certain additives.

Probably the easiest solution if a machine must operate under wet conditions is to choose a lubricating grease containing a soap which is water-repellent, such as aluminum, calcium, barium, lithium or strontium. However, this measure may not be sufficient

Table 2—Synthetic Fluids for Use in Greases

Fluid	Probable Texture	Temperature Range* (F)	Water Resistance
Silicones	Smooth	—80 to 500	Satisfactory
Diesters	Smooth	—65 to 250	Satisfactory
Polyalkylene glycols and derivatives	Smooth	—50 to 300	Satisfactory
Fluorocarbon polymers	Smooth	—45 to 480	Satisfactory†

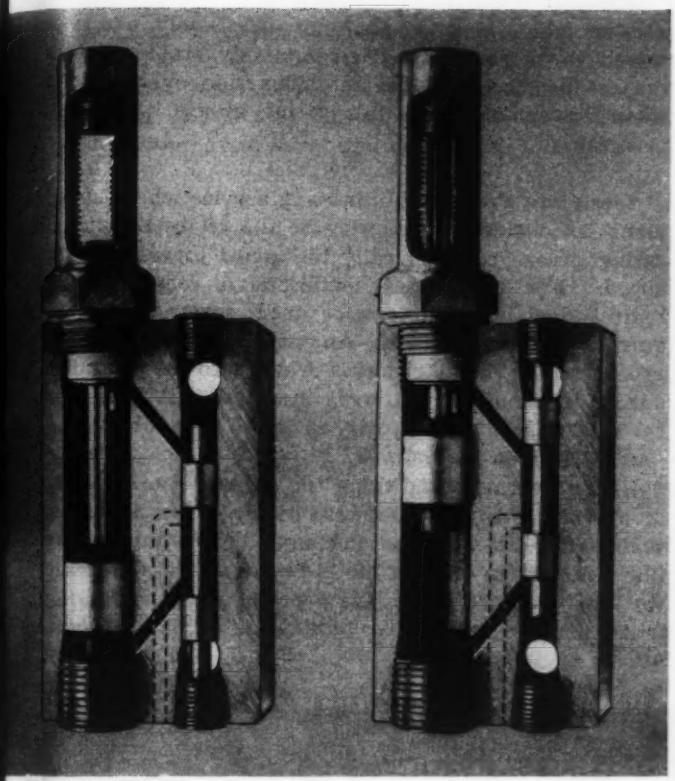
*Fluidity standpoint only. †Particularly resistant to corrosive chemicals and oxidation.

Table 3—Viscosity of Oil in Greases*

Temperature (F)	Speed Factor, 1000 DN†	Viscosity§ (SUS at 100 F)
32 to 150	< 75	150 to 600
	75 to 200	100 to 300
	200 to 400	70 to 200
	> 400	50 to 150
150 to 200	< 75	600 to 1200
	75 to 200	300 to 600
	200 to 400	150 to 300
	> 400	100 to 200
200 to 250	< 75	1100 to 3000
	75 to 200	700 to 2100
	200 to 400	400 to 900
	> 400	300 to 600

*Courtesy Gulf Oil Corp. †D=Bearing bore diameter, millimeters; N=Speed, rpm. §Higher viscosities apply to lower speed factors and higher temperature ranges, and vice versa.

[1]References are tabulated at end of article.



Photos, courtesy Farval Corp.

Fig. 6—Hydraulically operated grease valve for accurately controlling the amount of grease fed to each bearing

to keep machine elements in good condition. Possibly, when a grease is specified, the presence of a corrosion inhibitor should be insisted on if wet conditions prevail.

Importance of this factor is brought out by comparative tests in which No. 204 ball bearings were packed two-thirds full of various lubricating greases and held in a humidity cabinet under 100 per cent humidity at a temperature of 120 F. At the end of 6 months, the condition of the bearings was:[1]

CALCIUM BASE: Rough turning; no visible rust.

SODIUM BASE: Rough turning; lubricating grease entirely gone; considerable rust.

ALUMINUM BASE: Difficult to start; no visible rust.

LITHIUM BASE: Difficult to start; no visible rust.

LITHIUM BASE PLUS RUST INHIBITOR: Satisfactory in all respects.

Structure Changes in Service: When in service lubricating greases are subjected to shear which flexes the soap fibers and tends to break them. As a consequence, the lubricant softens. The structure of most greases is slowly rebuilt after shear ceases. Outside the area of movement, therefore, the lubricating grease has about the initial consistency and thus still acts as a seal to any softer lubricant which may be in the active zone.

A supplier will seldom recommend a lubricating grease which shows excessive softening in service. For a control on this factor, the Anti-Friction Bearing Manufacturers' Association has developed the BEC Grease Testing Machine, *Fig.* 3, which evaluates running torque registered during the test of a lubricating grease and also indicates any change in structure during a test.

Another method of evaluation of changes due to temperatures up to 220 F, or due to shear, is by means of the ASTM wheel-bearing lubricant tester, *Fig.* 4. In this machine, bearings packed with the lubricating grease are run for 6 hours at a temperature of 220 F, and a speed equivalent to either 40 or 60 mph.

Stability to shear or working in a lubricating grease depends upon both the nature of the soap fibers and their concentration. Such fibers should have a high length-to-diameter ratio and resist breaking into shorter fragments. Coupled with this is the bonding or physical attraction of the fibers for one another at the points of contact. Shear must overcome such attraction in order to reduce the consistency of a lubricating grease.

In ball bearings, most greases maintain lubrication by flowing into the tracks. A moderate rate of shear is sufficient to cause such lubricating greases to attain some degree of fluidity. High rates of shear tend to reduce the apparent viscosity to a value which is relatively close to that of the base oil. Thus a calcium-base lubricating grease was found[2] to have an apparent viscosity of 80 poises at a rate of shear of 15 sec^{-1} and 3.3 poises at the rate of shear of 10,000 sec^{-1}. Viscosity of the base oil was 2.1 poises. Since most lubricating greases are thixotropic (become liquid while being worked and solidify upon standing), lubricant forced outside the path of the rollers will set back, and thus the product will not throw off due to softening.

If a grease has both good adhesion and cohesion, it will tend to remain in a bearing. If the product adheres to the metal, and also has moderately good cohesion, lubricating grease will be drawn into the bearings and a circulation takes place.

Stability of lubricating greases both as to oxidation resistance and separation of oil can be graded roughly according to the deterioration time as:

Unstable	6 to 8 months
Moderately stable	8 to 18 months
Stable	Over 18 months

Any of the lubricating greases mentioned in this article can classify in any one of these three divisions, depending upon the stability of the mineral oil and the inhibitors employed.

Time Limitations: When grease is to be applied at frequent intervals, that is, as often as every few days or even weeks, time limitation is not pertinent. Some "lubricated for life" bearings are being used, and for these, confirmation that the lubricating grease will not deteriorate over a period of years should be sought. Accelerated oxidation tests permit such evaluation.

Oil Separation: Oil in a lubricating grease may be immobilized or held by capillary forces in the interstices of a tangle or irregular latticework of small

soap fibers, by direct combination or sorption (retention on the latticework surface) of solvent molecules, or by penetration of free molecules of solvent between the interlacing structure in order to relieve strains existing in the fiber framework.

Thus, if the gel structure contracts, oil can be forced out of the grease system and "syneresis" results. This situation is very unusual in a properly manufactured lubricating grease, but what is termed "bleeding" may occur. Bleeding may be considered leakage of oil from the lubricating grease due to deficient gel structure. This condition will be aggravated by too small a percentage of soap and thus can be expected in the softer grades of lubricating greases.

Since the forces which immobilize the fluid in a lubricating grease can be overcome by increase in either temperature or pressure, some oil separation may occur due to such forces. As long as bleeding does not result in abnormal dripping of oil from the lubricated part or in a considerable increase in soap concentration in the residual lubricating grease, this characteristic may be a good thing. In fact, lubricating greases which bleed oil, but not excessively, are preferred to those which are completely stable in this respect because the free oil helps tide over periods when movement of the lubricating grease itself may be retarded.

Speed and Pressure: In bearing service where speed alone is considered, viscosity of the oil in the lubricating grease can generally be varied inversely with speed. For high-speed conditions a comparatively light bodied lubricant can be used; lower speeds require a heavier product. As speed increases the degree to which the lubricant is drawn into the clearance spaces by capillary action is increased. A basis for the selection of the viscosity of an oil in a lubricating grease is given in TABLE 3.

Under average conditions the greater the existing or operating pressure between two bearing elements, the heavier or more viscous must be the lubricating film in order to prevent metal-to-metal contact. Safe working pressure, of course, depends upon the bearing metal used.

Consider Grease for . . .

Low Speeds or High Loads: Extreme operating conditions such as high pressures, low speeds, shock loading, and intermittent or reversing operations can often best be handled with grease.

Inaccessible Locations: Infrequent application is needed, since grease has relatively long life.

Dusty or Dirty Locations: Grease acts as a seal to prevent entrance of dirt or soot into the bearing.

Exposed Bearing Surfaces: Since grease clings to metal, it can effectively protect exposed bearing surfaces such as gears or slides from corrosion. Properly selected types can resist the washing action of water.

Vertical Bearings: Grease lubrication often simplifies design.

Protection from Dripping and Spattering: Grease can usually be used safely on textile and food machinery with less chance of contamination or staining.

Consider Other Lubricants for . . .

High Speeds: At very high speeds, additional heat may be generated by fluid friction in greases.

Low-Torque Applications: Greases, particularly the heavy plastic products, may cause appreciably higher torque.

Heat Dissipitation: Although greases can withstand relatively high temperatures, other lubricants can usually dissipate bearing heat more effectively.

Open Gears or Chains: Grease lubrication may be entirely satisfactory, but if gears or chains are not tightly housed, better adhesion and less throw-off may be attained with oil residue.

Complex Bearing Lubrication Layouts: Distribution or lubrication systems for grease are generally not as simple as those for oil.

Lubricating greases containing oils of 400 Saybolt universal seconds (SUS) at 100 F or heavier will withstand pressures of 6000 psi. Tested on roller bearings operating at 955 rpm and at a pressure of 4620 psi, the following greases showed no failure of the bearing after prolonged tests:

1. A sodium-base grease containing a 500 SUS at 100 F oil.
2. A lithium-base grease containing a 700 SUS at 100 F oil.
3. A barium-base grease containing a 600 SUS at 100 F oil.

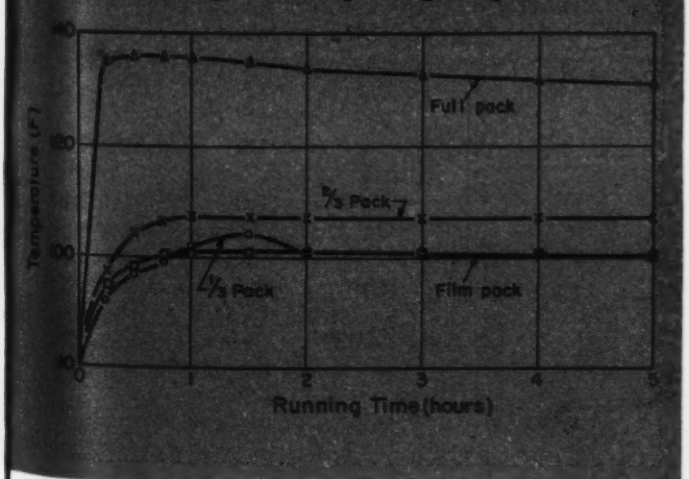
Large roll-neck bearings operating at varying speeds with pressures of 600 to 1700 psi are lubricated with grease.

Lubricating greases can be provided with extreme-pressure qualities by the use of certain additives. Such EP lubricants withstand pressures up to possibly 25,000 psi, and are generally for sliding or a combination of rolling and sliding such as in spiral-bevel or Hypoid gears. Ordinary rolling friction does not demand such a quality.

Solvents and Chemicals: Addition to a lubricating grease of a solvent which greatly affects either the oil or the soap fibers will destroy the grease structure. The best remedy for such a situation is to provide as tight a seal as possible to prevent entry of the solvent. If such a seal cannot be provided, certain specialty greases are available which will withstand solvents. These include silicone types and fluorocarbon polymers.

Lubrication in the presence of corrosive chemicals calls for specialty lubricating greases. If the contaminant is an alkali, a lubricating grease in which the soap is made from a similar base should solve the problem. If the machine operates in the presence of strong acids, special acid-proof bearings will be required, and perhaps these can be lubricated with solid materials such as graphite. Oxidizing chemicals may require fluorocarbon polymers. For mild conditions the harder grades of lubricating greases will usually serve.

Fig. 7 — How amount of grease packed into bearing affects operating temperature



Selection of a Grease: Lubricating greases are available in a wide variety of types and characteristics. Unfortunately, many suppliers prefer to market such products entirely by trade name, and thus do not give specifications. However, specifications are available upon request, and it is often preferable to state general characteristics on lubrication recommendations rather than to list trade names.

Most lubricating greases produced from synthetic fluids and nonsoap thickening agents are not as available as standard soap greases, and are more expensive. For normal service such lubricants are not required and in the main have specialized applications.

Copper phthalocyanine suitable for use as a thickening agent, for example, may cost $20 per pound. Quantities available at the present time are extremely limited; a lubricating grease consisting of silicone fluid thickened with copper phthalocyanine, developed at one of the larger research laboratories, is produced in 100-pound lots. Prices up to $90 per pound have been quoted for polymerized fluorocarbons; however polymerized chlorofluorocarbons—almost as resistant to acids, alkalies and oxidizing agents—have been quoted as low as $15 per pound. The future, therefore, for these types of lubricating greases looks bright, but present applications are limited by the current supply status.

Method of Application: While the particular equipment and connections for application of lubricating grease to a specific machine will depend upon the size, probable use, and design of the equipment, centralized lubrication should be considered. A complete system layout, *Fig.* 5, permits one operator to service accurately a large number of bearings in a fraction of the time required if individual servicing were required.

It should be emphasized that over-lubrication may be almost as harmful as under-lubrication. For this reason, the lubricating grease delivered to each bearing should be carefully controlled. One possible method is with hydraulically operated grease valves, *Fig.* 6.

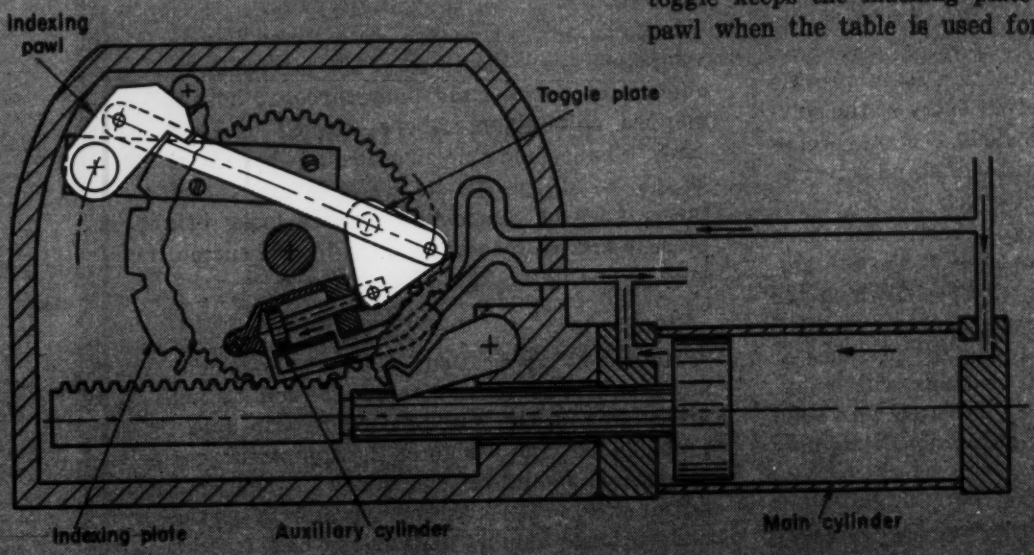
Consideration should be given to the use of relief valves on the housings of antifriction bearings which are to be serviced with lubricating grease. Experiments with ball bearings in which various amounts of lubricating grease were used, summarized in *Fig.* 7, show that temperature rises with full packing.[3] There is also the possibility of breakage of seals, and full packing also contributes to aeration which, in turn, promotes oxidation.

REFERENCES

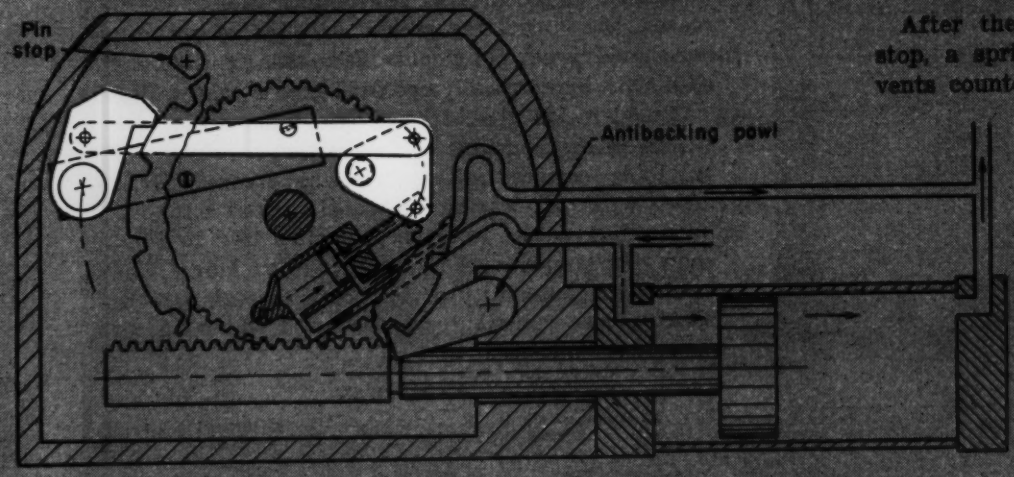
1. T. G. Roehner and E. S. Carmichael—"Evaluation of Water Resistance Properties of Lubricating Greases," *Institute Spokesman*, Vol. 11, No. 6, 1947, Page 4.
2. S. R. Pethrick—"The Testing of Greases for Ball Bearings," *Petroleum Institute Journal*, Vol. 31, 1945, Page 248.
3. T. G. Roehner—"General Grease Characteristics Versus Bearing Requirements," *Lubricating Engineering*, Vol. 6, 1950, Page 224.

Toggle-Locked Pawl Operates Index Table

RAPID and positive engagement and release of an indexing pawl in the redesigned A. K. Allen Co. indexing table is accomplished by an auxiliary air cylinder and toggle mechanism. Providing a mechanical lock in the indexing position, the toggle keeps the indexing plate from running away from the pawl when the table is used for high-inertia loads.



The indexing pawl, auxiliary cylinder and triangular toggle plate are all mounted with pivot studs on a rack-operated gear. On the indexing stroke of the main cylinder and rack, the indexing pawl is engaged with a notch on the index plate by the auxiliary toggle mechanism. In this position the pawl is mechanically locked, since two studs on the index plate and the pawl stud are toggled.



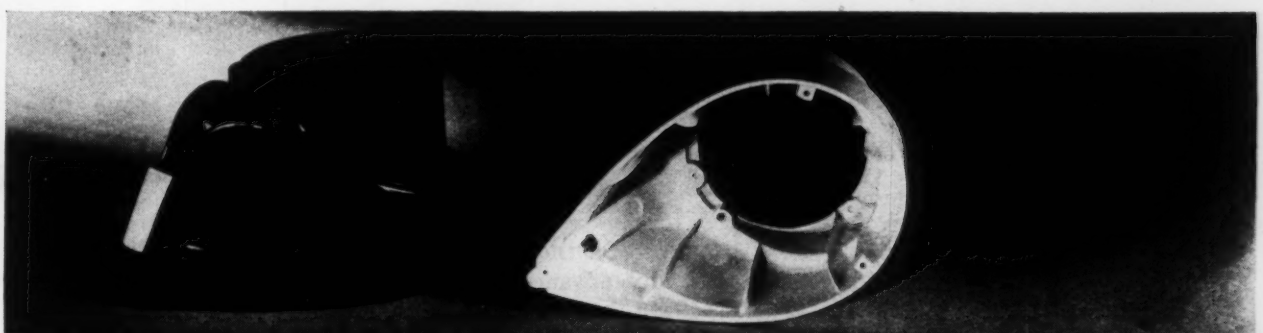
After the pawl is indexed against a pin stop, a spring-loaded antibacking pawl prevents counterclockwise rotation. On the return stroke, the indexing pawl is first shifted out of engagement, then guided to the next correct notch by a baffle plate (not shown) fixed to the indexing plate. Thus, although all tables are supplied with 24 notches or indexing positions, 4, 6, 8 or 12-position indexing can be selected by adding one of the replaceable baffles.

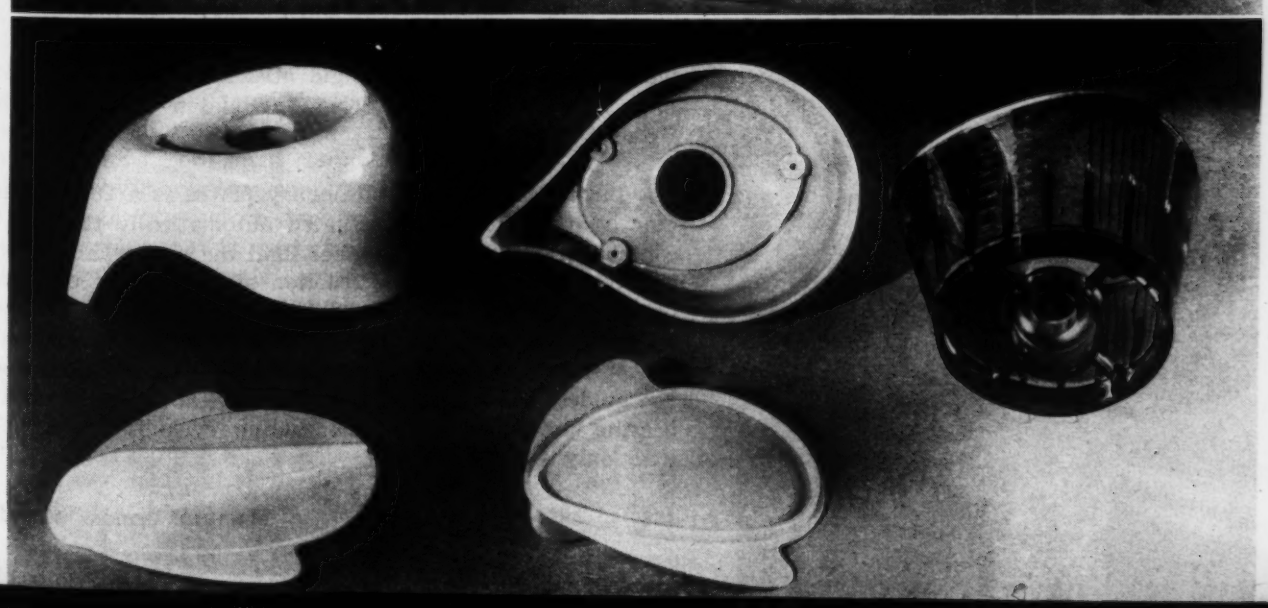
NTEMPORARY DESIGN

Color Styling Varied with Two-Piece Plastic Base

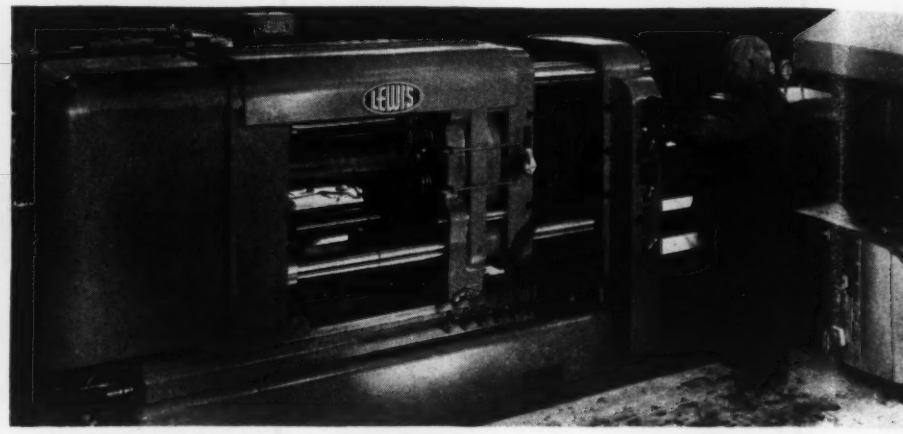
DISTINCTIVE color combinations for any market are obtained on the liquefier and mixer manufactured by Hollywood Liquefier Co. through use of a two-section plastic base. Four colors, white, ivory, blue and red, are available in both halves of the base to harmonize with any color scheme—without extensive changes in production schedules. Operating parts of the unit consist of a motor driving eight serrated stainless-steel mixing and liquefying blades mounted permanently in the bottom of a clear Tenite cellulose-acetate bowl, which is removable for pouring.

The base section is produced in three parts, the upper and lower halves plus a small plastic insert mounted in the lower half but matching the top-half color. All base parts and the lid cover are injection molded of Plaskon urea. Holes are drilled and tapped after molding to receive the motor, switch and cord, and a base plate with rubber feet is added. The motor has a rated operating speed of 25,000 rpm, sufficient to liquefy solids completely at high speed, or to mix and blend at low speed.

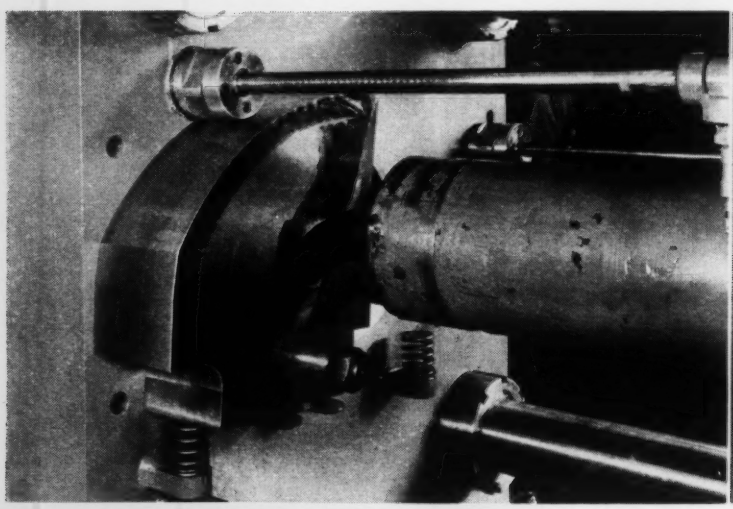


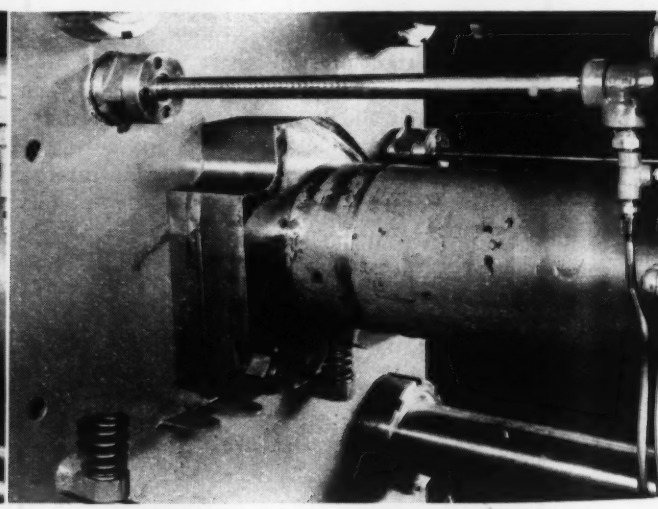


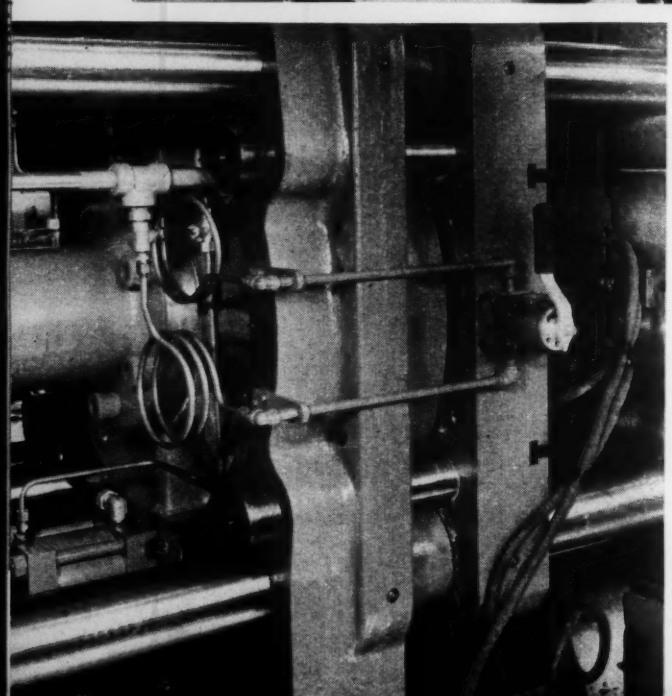
New Die Clamping Principle for Casting Machine



FINAL clamping pressure of 650 tons is developed by a two-stage hydraulic clamping mechanism in the new die forge casting machine developed by Lewis Welding & Engineering Corp. The machine employs the so-called "cold chamber" method of injection but also introduces a new injection principle giving a rapid fill and unusually high final squeezing pressure. In essence, the injection system consists of two concentric pistons. The smaller piston, traveling at variable speeds up to 810 fpm, fills the die cavity rapidly with molten metal. As resistance is encountered, the larger diameter piston is activated to provide a maximum pressure of 100,000 pounds with 2100 psi line pressure, variable to meet casting requirements. Up to 9.5 pounds of aluminum can be injected per shot.



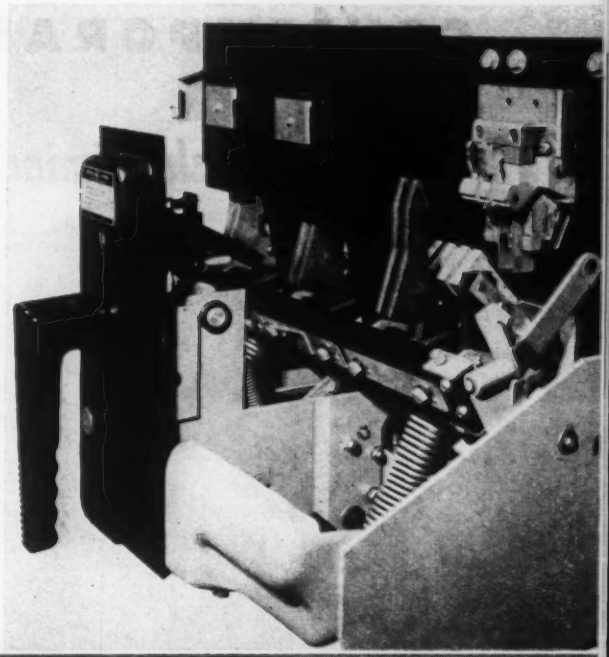




On the clamping stroke, a small hydraulic cylinder rapidly advances the "stationary" platen, on which the moving half of the die is mounted, to a position where the die faces are separated by a fraction of an inch. A mechanical locking device then drops into place behind the platen ram to provide a rigid structure capable of taking high compression loads from the platen to the machine frame.

Incorporated in the stationary platen is a 28-inch diameter hydraulic cylinder, actuated automatically through the control circuits, which supplies final die closing and locking action. Requiring only a fraction of a gallon of oil, stroke of this large cylinder is so short that only a few tenths of a second are required for final clamping action. Ball-and-socket like action of the cylinder, plus liberal clearances in the guides, permits die misalignment without loss of uniform bearing pressure. The total casting cycle is accomplished with only 4 gallons of oil.

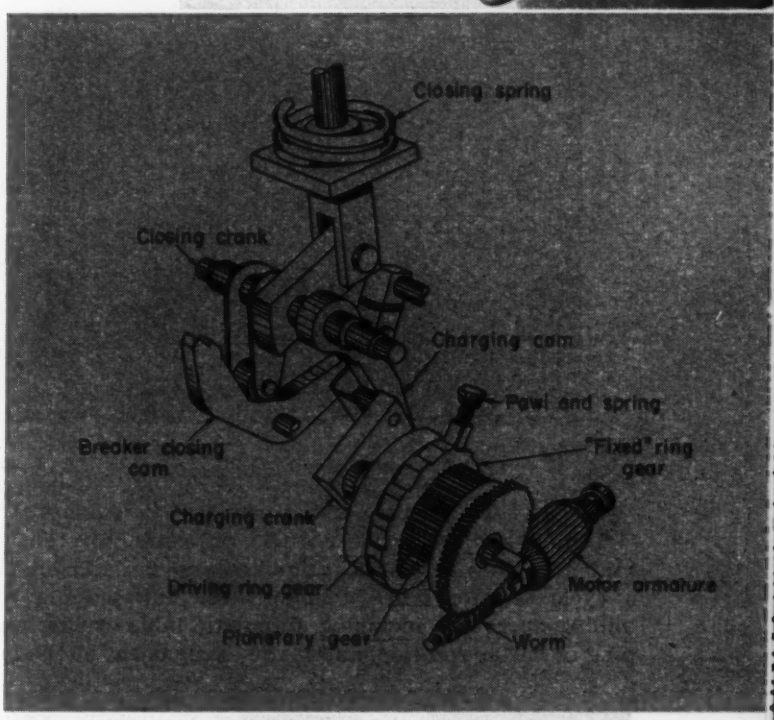
Mechanism Stores Energy in Air Circuit Breaker



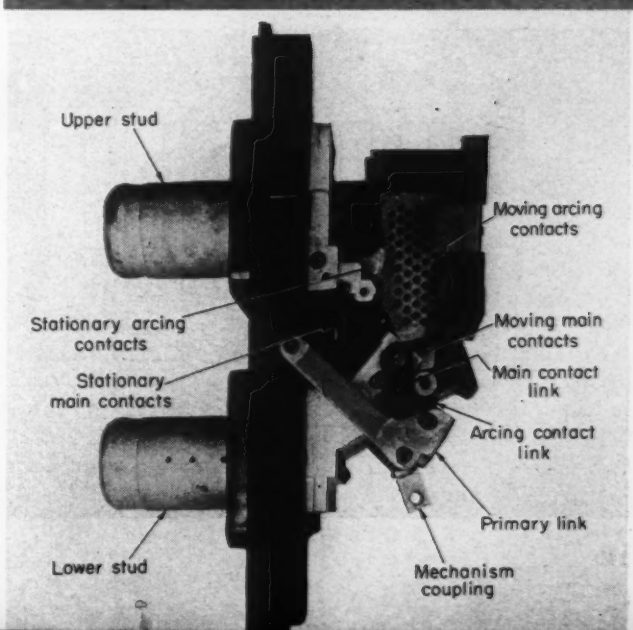
TWO ingenious mechanisms are incorporated in a new line of General Electric low-voltage air circuit breakers having interrupting ratings of 50,000, 75,000 and 100,000 amperes. High contact closing speed, and the ability to close and latch against the breaker's full interrupting rating, are both produced by a stored energy mechanism. In addition, a new linkage operates main and arcing contacts in the correct sequence, regardless of magnetic forces resulting from short-circuit current through the structure.

Energy is stored in a closing spring, compressed by a cam driven through a reduction unit. The reduction of 1000 to 1 is accomplished by a combination of worm and planetary gearing. A freely rotating planetary gear, eccentrically mounted on the worm wheel, meshes with two ring gears, one having one more tooth than the other. Thus, for every revolution of the worm wheel the ring gear driving the charging crank gets a relative angular motion of one tooth.

The "fixed" ring gear is held stationary by a pawl until the charging crank passes dead center, after which it acts as an over-running clutch. In this way, free movement of the breaker closing cam is permitted on the closing stroke, restricted for smooth operation only by the guiding surface on the charging cam. Flywheel action of the rotating ring gears returns energy to the spring system at the end of the closing stroke, aiding closing under sudden magnetic and mechanical loading, or partially recharging the closing spring under normal or no-load conditions.

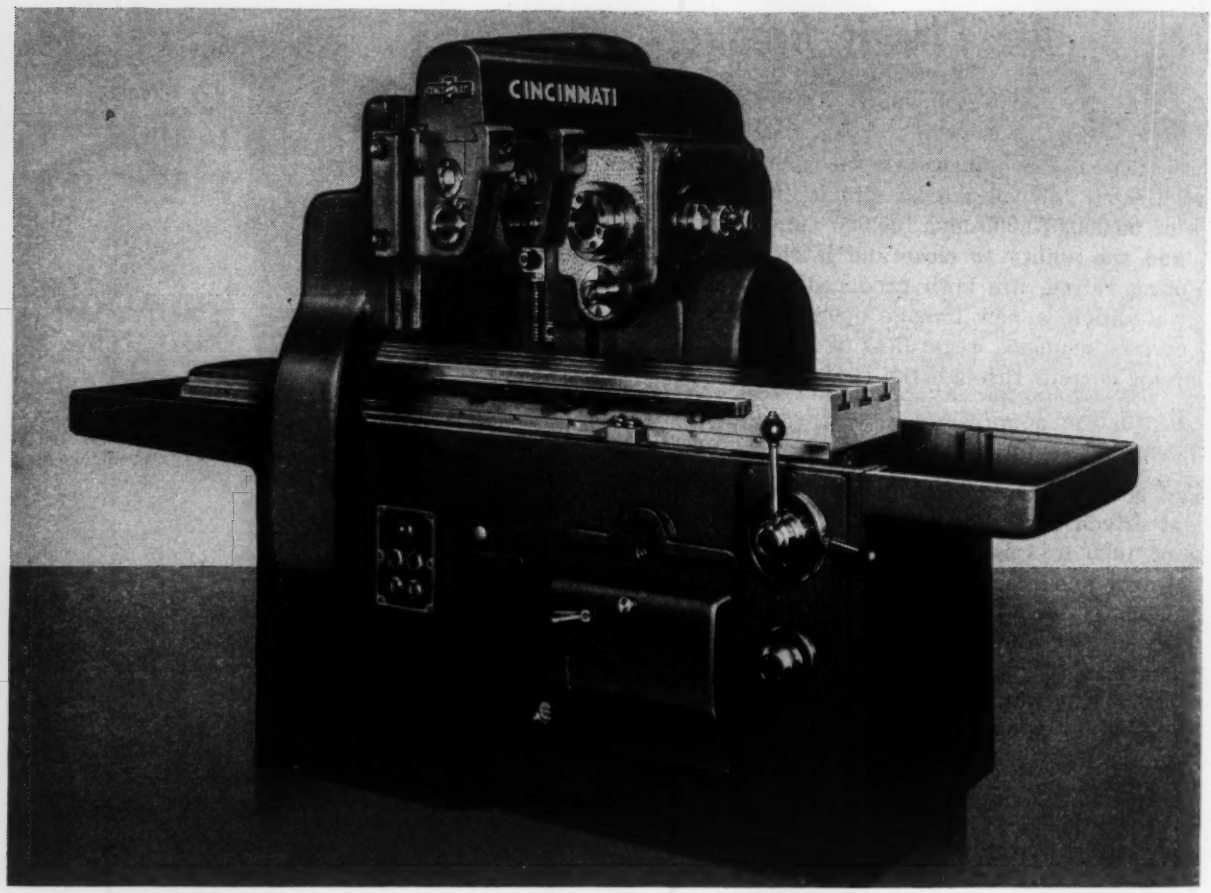


Contact linkage is coupled to the breaker closing cam. Moving main contacts pivot on a current-carrying pin mounted in the lower stud, while moving arcing contacts are similarly pivoted at the center of the moving main contacts. The linkage system, operated by the primary link, positively closes the arcing contacts before main contacts close. On the opening operation, main contacts open first and have adequate gap before the arcing contacts are parted, an action that is mechanically fixed and cannot be altered by magnetic forces. Stationary main and arcing contacts, supported on silver-plated pins in the upper stud, are spring-loaded to provide necessary contact wipe. These flexible members are located inside the current loop so that magnetic forces under short-circuit conditions add to the normal spring loading.

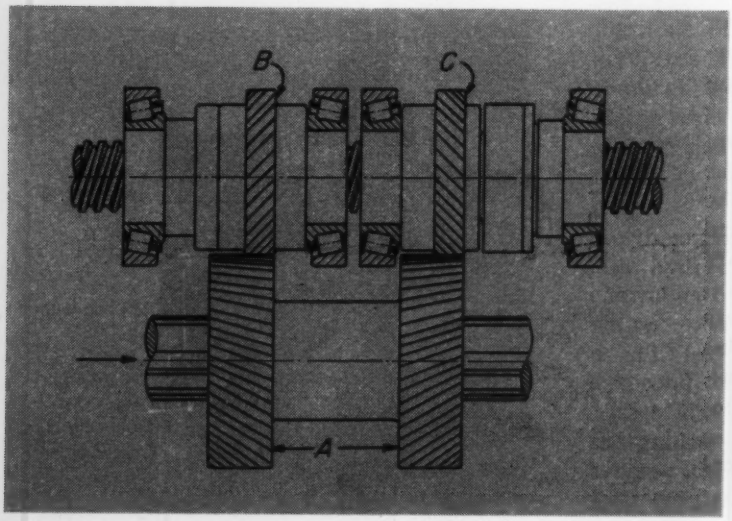


CONTEMPORARY DESIGN

Backlash Eliminator Permits Two-Direction Milling



AMONG the features of the new 2-24 Cincinnati automatic milling machines is a backlash eliminator that permits taking a cut in both forward and reverse directions. Through a cycle selector unit, a single lever initiates the complete milling operation, including automatic table cycling and stopping of cutter rotation, automatic engagement of the backlash eliminator on vertical feed or when the table traverses at a feed rate, and automatic up and down cycling of the spindle carrier on rise-and-fall styles. Actually a cam assembly on a short demountable shaft in the bed, the cycle selector may be quickly changed. Dogs control length of stroke, and a table cycle-reverse device can reverse feed and traverse operations.



Elimination of backlash in the table feed nut is accomplished through use of a combination drive gear with right and left-hand helical teeth. Cluster gear *A* is the driver, and is secured to a piston in the shaft. Piston pressure tends to move gear *A* laterally and to rotate gears *B* and *C*, mounted on the table feedscrew, in opposite directions, thus eliminating backlash between the table feedscrew and nuts as long as pressure is applied. During rapid advance and retraction cycles, pressure is automatically released for free operation.

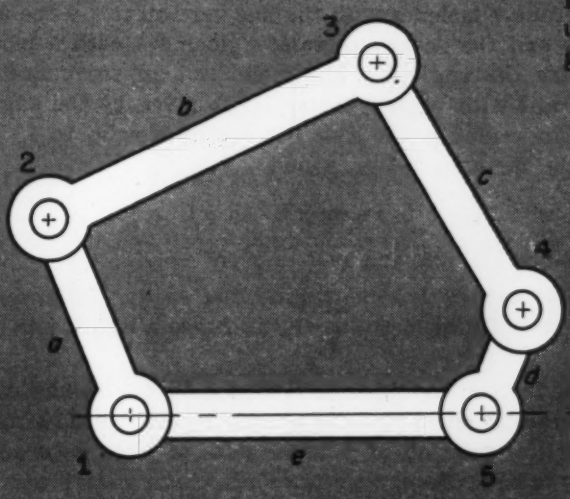


Fig. 1—The five-bar linkage as nonpositive chain with no utility for mechanisms

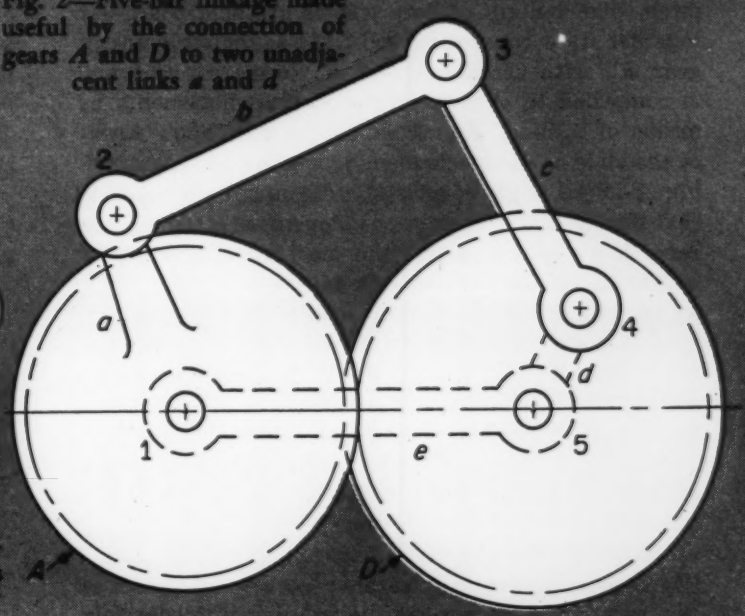


Fig. 2—Five-bar linkage made useful by the connection of gears *A* and *D* to two unadjacent links *a* and *d*

Eccentric Gear Mechanisms

. . . for producing varying angular velocity with circular spur gears

By Paul Grodzinski
London, England

A VARIATION in angular velocity of a driven member during one full rotation of the driving member is sometimes required in machines. Since the prime movers usually produce a nearly uniform angular velocity, additional mechanisms are necessary to produce such variations. These variations may range from, say 0.5 to 2.5, if the average velocity is 1. Movements with a ratio of zero or even negative values may be included; in the first instance, the movement would come to a standstill, and in the second, the driven member would move temporarily backwards. Such movements are usually obtained through cam drives, indexing and ratchet mechanisms, etc.

A great variety of movements can be obtained from the simple eccentric gear mechanism which contains only circular spur gears fixed to eccentric axes. These mechanisms can be derived from a five-bar linkage, *Fig.* 1, which evidently is not a positive mechanism. It becomes positive if two members, separated by a third one, are coupled, *Fig.* 2. Besides a connecting rod, two gear wheels *A* and *D* may be applied, connected to the members *a* and *d*, respectively. This combined crank and gear mechanism is closely related to the elementary positive chain with six members and seven rotating joints, but in this instance consisting of five members, five joints and one higher pair. The actual mechanism under discussion is derived if, for example, joint 3 becomes a slide (moves into infinity) and the two gears become of equal diameter, *Fig.* 3.

The basic mechanism, *Fig.* 3, consists of a gear *R*

rotating about an eccentric axis (eccentricity = r) and driving the other wheel R' of the same size and pitch. The centers of both wheels are held positively together by a connecting rod l. An eccentric point of gear R', with eccentricity = r', forms an axis and is compelled to perform reciprocating movements by means of a slide. *Fig.* 4 shows the maximum stroke of the slide of the mechanism depending on the adjusting or initial angle of gear R'. The upper curve shows that for a distinct angle a_0, dependent only on the ratio $E = r/R = r'/R'$, the mechanism produces a minimum stroke. When this initial adjusting angle a_0 is chosen, under certain conditions the eccentric axes of both gears might be made stationary and also the connecting rod l omitted. Then a mechanism results as simple as that consisting of two elliptical gears rotating about their focal centers.

This adaptation is permissible to a distinct degree as will be shown by the following discussion, if the always remaining small stroke of the mechanism is absorbed by the clearance between the teeth, and if the higher tangential clearance at several points of the rotation does not act harmfully. Alternatively, the basic mechanism according to *Fig.* 3 can be applied, perhaps with some simplifications which are explained later.

Basic Law of Movement: The theory of this mechanism has been given by F. Grashof and later on by the author, so that here only the basic results need be mentioned.

In the schematic illustration, *Fig.* 5, gear R is pivoted in point 1, situated eccentrically relative to center 2 (eccentricity = r) and drives gear R'. Eccentric axis 4 of driven gear R' (eccentricity = r') is guided in a slide, the direction of which coincides with line 1-4. The centers of both gears are coupled by connecting rod $l = R + R'$. Points 1, 2_0, 3_0 and 4_0 give the starting position with angle 4_0-1-2_0 = 90 deg for driving crank r, angle a for crank r', and angle b for connecting rod l. In any arbitrary position, shown in full lines in *Fig.* 5, the eccentric crank r includes with the line vertical to 1-4 the angle p and the eccentric crank r' includes with a parallel line the angle p'. The inclination of the connecting rod l with regard to line 1-4 is given by the angle q. The center of the slide has moved from 4_0 to 4. Then the distance 1-4 = x and

$$x = l \cos q + r (\sin p + \sin p') \quad \ldots\ldots (1)$$

Since $l = 2R$ and $r/R = r'/R' = E$,

$$x = 2R \cos q + \frac{E}{2} (\sin p + \sin p') \quad \ldots\ldots (2)$$

A further condition is obtained by the rolling of the gears R and R' on their pitch circles, considering the initial position of p to be zero, of p' to be a and of q to be b. Then,

$$p - q + b = p' - a + q - b \quad \ldots\ldots (3)$$

which may also be written

$$q = \frac{a}{2} + b - \frac{p' - p}{2} \quad \ldots\ldots (4)$$

Equations 1 and 4 are made more amenable to evaluation by use of the combined angles $v = (p' - p)/2$ and $w = (p' + p)/2$ instead of the angles p, p' and q.

Furthermore, if $g = (a/2) + b$,

$$q = g - v \quad \ldots\ldots (5)$$

From *Fig.* 5 a third geometrical relationship is apparent:

$$\sin q = -\frac{r}{l} (\cos p' - \cos p)$$

$$= -\frac{E}{2} (\cos p' - \cos p) \quad \ldots\ldots (6)$$

Equation 6 is a simplified expression for position

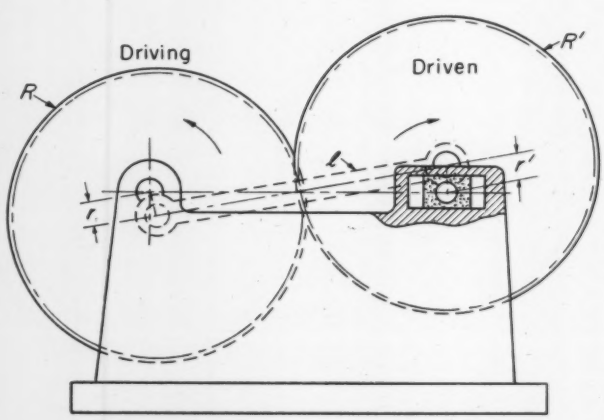


Fig. 3—The eccentric gear mechanism with one sliding pair and equal-size, equal-eccentricity gears

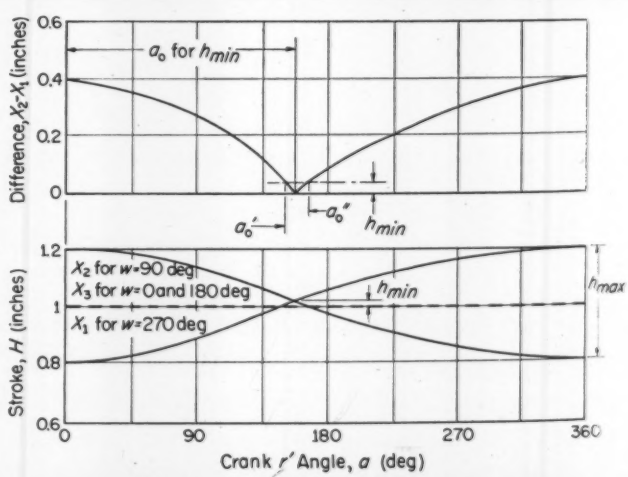


Fig. 4—Lift of mechanism plotted against the adjusting or initial angle a revealing the phenomenon of a lift nearly zero

$1\text{-}2_0\text{-}3_0\text{-}4_0$. From the foregoing equations, the following basic relationship can be developed:

$$\cot v = \frac{E \sin w + \cos g}{\sin g} \quad \ldots\ldots (7)$$

Expressions for sin v and cos v can be derived from Equation 7 and introduced in Equation 1:

$$x = 2R\,[\cos(g - v) + E \sin w \cos v] \quad \ldots\ldots (8)$$

Equation 7 can be rearranged so that v is eliminated and x is expressed as a function of w:

$$x = 2R\,[\sqrt{(\cos g + E)^2 + \sin^2 g} - \sqrt{(\cos g - E)^2 + \sin^2 g}] \quad \ldots\ldots (9)$$

Equation 9 shows that the extreme values for x are given by $w = 90$ deg and $w = 270$ deg. Thus the stroke of the slide is

$$H = 2R\,[\sqrt{(\cos g + E)^2 + \sin^2 g} - \sqrt{(\cos g - E)^2 + \sin^2 g}] \quad \ldots\ldots (10)$$

The condition for the application of the mechanism is that the stroke should become a minimum. Obviously the two values under the radical of Equation 10 become equal for cos $g_0 = 0$, that is, when $g_0 = 90$ deg.

Of course, the actual stroke of the mechanism is not absolutely zero between the crank positions for $w = 0$ and 180 deg. There remains a sinusoidal movement, but of very small amplitude. This condition is clearly shown in *Fig.* 6 for a mechanism with $R = 5$ inches and $E = 0.2$ for adjustments of cos $g = 0.5$ and cos $g_0 = 0$. Although cos $g = 0.5$ yields maxima and minima for $w = 90$ deg and $w = 270$ deg, in the case of cos $g_0 = 0$, there is a small movement between $w = 90$ deg and $w = 180$ deg. The maximum lift for the mechanism with minimum stroke, at $g_0 = 90$ deg, becomes

$$h_{min} = \frac{H}{2R} = \sqrt{1 + E^2} - 1 \approx \frac{E^2}{2} - \frac{E^4}{8} \quad \ldots\ldots (11)$$

Usually, the first approximation $h_{min} = E^2/2$ is sufficient. From the condition $g_0 = (a_0/2) - b_0 = 90$ deg,

$$\sin b_0 = \cos \frac{a_0}{2} = \frac{E}{\sqrt{1 + E^2}} \approx E\,(1 - E^2) \quad \ldots\ldots (12)$$

For obtaining the mechanism of minimum stroke, the adjustment of angle a_0 is not very critical, as can be seen from another consideration. The stroke for the general mechanism, not that for minimum stroke, can be written approximately

$$h = 2E \cos g \left(1 - \frac{E}{2}\right) \quad \ldots\ldots (13)$$

and assumed equal to h_{min} according to Equation 11. Then when resolving cos g,

$$\cos g = \frac{E}{4}\left(1 - \frac{E}{2}\right) \quad \ldots\ldots (14)$$

which has two solutions for g_0:

$$\cos g_0 = \pm \frac{E}{4}\left(1 + \frac{E}{2}\right) \quad \ldots\ldots (15)$$

From this relationship two further values for the initial or adjusting angle a_0' and a_0'' result, between which the value a_0 determined by Equation 12 lies. The difference between the angles a_0' and a_0'' determines a kind of allowance for the adjusting angle. *Fig.* 4 shows on its lower part curves for x plotted against the angle a. One has to distinguish between three curves: x_1 for

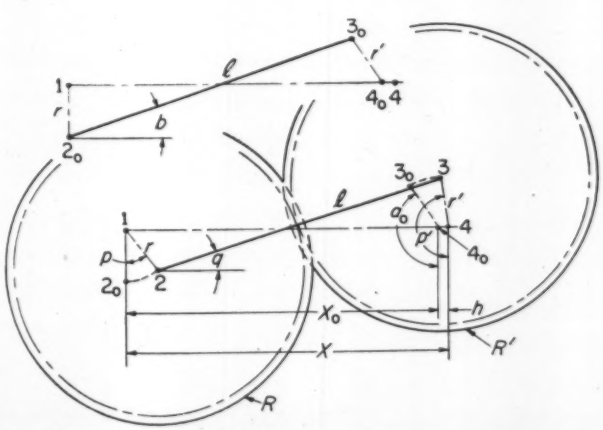
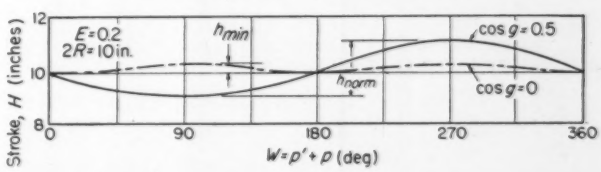


Fig. 5—Left—Layout of mechanism for derivation of pertinent relationships

Fig. 6—Below—Influence of angle $g = a_0/2 - b$ on the lift of the mechanism



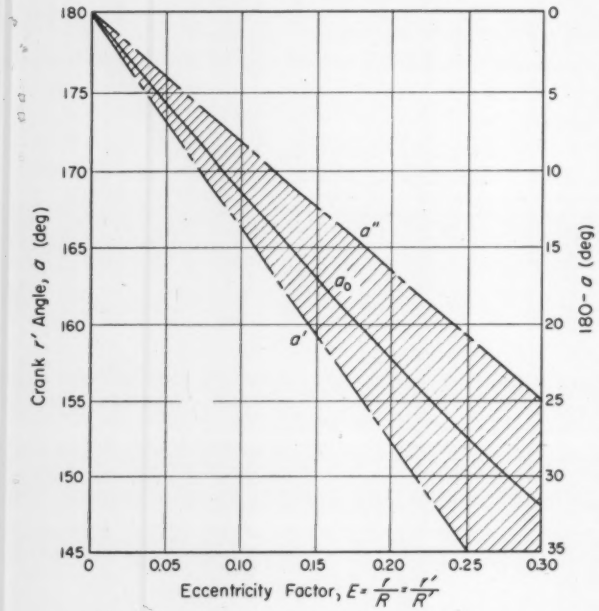


Fig. 7 — Left — Relation between adjusting or initial angle a_0 and eccentricity E

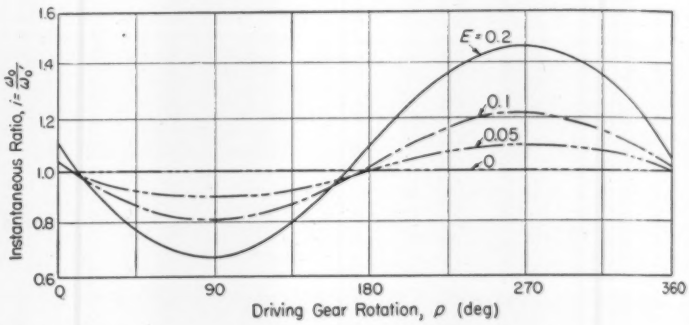


Fig. 8—Above—Angular velocities in relation to driving angle p

$w = 270$ deg, x_2 for $w = 90$ deg (both of sinusoidal form and intersecting) and x_3 for $w = 0$ and 180 deg shown in dotted lines. The latter is independent of angle g and therefore a. The difference between this line and the crossing point determines the lift or stroke of this mechanism. In the upper part of *Fig.* 4 the lift between the sinusoidal curves (a) is shown and the dot and dash horizontal line indicates h_{min}. This shows clearly that in front of and behind a_0 two other values a_0' and a_0'' lie for which practically no greater lift will be obtained. These values have been determined by calculation with the foregoing equations.

In *Fig.* 7 the relationship between the values a_0, a_0' and a_0'' and E is given. This curve is represented up to $E = 0.3$, but can be easily extended for higher values.

Angular Velocities: In order to determine the eccentricity E of a mechanism when a distinct speed variation is required, the momentary angular velocities have to be known. The mechanism can be considered as a kind of cam or roller gear. If R_0 and R_0' are the distances of the point of contact from the centers of rotation and $\omega_0 = dp/dt$, $\omega_0' = dp'/dt$ are the momentary angular velocities in radians, as the flanks of teeth are compelled to roll,

$$R_0\,\omega_0 = R_0'\,\omega_0' \quad \ldots\ldots (16)$$

The momentary transmission ratio is

$$i = \frac{R_0'}{R_0} = \frac{\omega_0}{\omega_0'} = \frac{dp}{dp'} \quad \ldots\ldots (17)$$

From the auxiliary relationships given prior to Equation 5, and after differentiation, $dp = dw - dv$ and $dp' = dw + dv$. Therefore,

$$i = \frac{dp}{dp'} = \frac{dw - dv}{dw + dv} = \frac{1 - \dfrac{dv}{dw}}{1 + \dfrac{dv}{dw}} \quad \ldots\ldots (18)$$

Equation 7 for the mechanisms with minimum stroke becomes $\cot v = E \sin w$ and after differentiation

$$\frac{dv}{dw} = -E \cos w \sin^2 v \quad \ldots\ldots (19)$$

Fig. 9—Polar diagram of angular velocities of driven gear. Driving gear rotates with constant speed (ω_0 = constant)

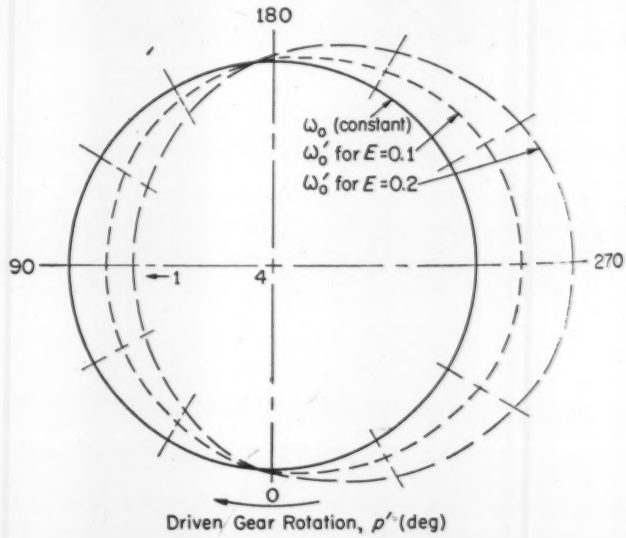


Table 1—Momentary Transmission Ratio

Ratio i	p (deg)	p' (deg)	v (deg)	w (deg)
1	0	a_0	$\frac{a_0}{2}$	$\frac{a_0}{2}$
$i_{min} = \frac{1-E}{1+E}$	90	270	90	180
1	180	$180-a_0$	$180-\frac{a_0}{2}$	$360-\frac{a_0}{2}$
$i_{max} = \frac{1+E}{1-E}$	270	90	90	360

Combining Equations 18 and 19 gives

$$i = \frac{1 + E \cos w \sin^2 v}{1 - E \cos w \sin^2 v} \quad \ldots\ldots (20)$$

Since in the extreme cases, cos w and sin v can assume as their highest values only unity and E remains usually smaller than 0.5, approximately

$$i = 1 + 2E \cos w \sin^2 v - E^2 \cos^2 w \sin^4 v \quad \ldots\ldots (21)$$

To determine the extreme values, TABLE 1 may be used. The extreme values i_{min} and i_{max} can be written approximately

$$i_{min} = 1 - 2E + 2E^2 \quad \ldots\ldots (22)$$

$$i_{max} = 1 + 2E + 2E^2 \quad \ldots\ldots (23)$$

The maximum ratio is, therefore,

$$n = \frac{i_{max}}{i_{min}} = i_{max}^2 = \left(\frac{1+E}{1-E}\right)^2 \quad \ldots\ldots (24)$$

or approximately

$$n \approx 1 + 4E + 4E^2 \quad \ldots\ldots (25)$$

In *Fig.* 8 for different values of E the ratio of the angular velocities $i = \omega_0/\omega_0'$ of the driven wheel are plotted against the angle of rotation p of the driving gear. The extreme values are always present for p = 90 and 270 deg independent of the eccentricity E, whereas the position of the values $\omega_0/\omega_0' = 1$ changes. This condition indicates that the stroke cycles are varying. Furthermore, with decreasing values of E, the differences between ω_0' and ω_0 become smaller and the points for $\omega_0/\omega_0' = 1$ approximate the values p = 0 and 180 deg.

A polar diagram of the angular velocities ω_0' is shown in *Fig.* 9 for gears of E = 0.1 and 0.2, drawn from the center of the driven wheel—that is, in relation to the angle p' of the driven wheel rotating with variable angular velocity. The extreme values are present in the direction 1-4, similar to elliptical gears rotating on their focal centers. The polar curves are symmetrical to this central line. To about E = 0.1, the diagram is approximately circular.

Design Factors: For the practical application of these mechanisms, usually one of the values i_{max}, i_{min} or n is prescribed. Then from TABLE 2 or *Fig.* 10, the necessary values for the design of the mechanism can

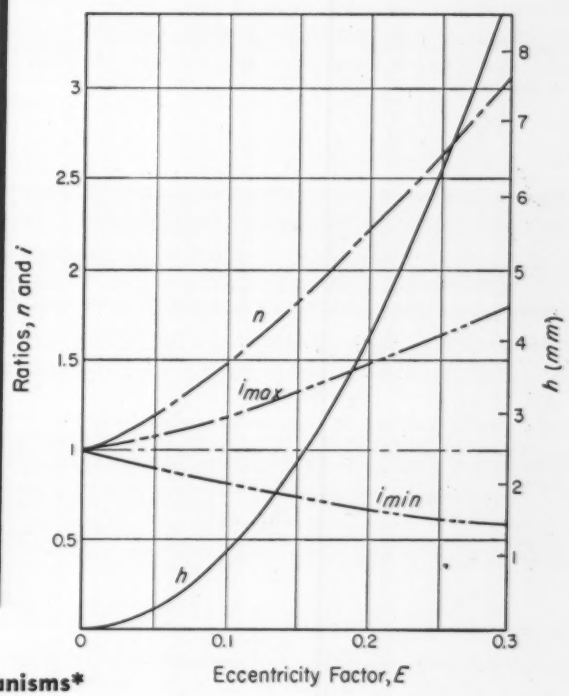


Fig. 10—Diagram of values necessary for design of a mechanism with minimum stroke

Table 2—Values for Minimum Lift Eccentric-Gear Mechanisms*

$E = \frac{r}{R}$	0.05	0.08	0.10	0.12	0.15	0.18	0.30	0.25	0.25
H	0.025	0.064	0.100	0.144	0.225	0.324	0.400	0.480	0.625
i_{max}	1.105	1.173	1.22	1.27	1.35	1.42	1.48	1.56	1.63
i_{min}	0.905	0.85	0.82	0.79	0.75	0.70	0.68	0.66	0.62
n	1/1.1	1/1.4	1/1.44	1/1.6	1/1.8	1/2	1/1.2	1/2.3	1/2.6
$180 - a''$	4	6.5	8	9.5	12	14.5	16	18	21
$180 - a'$	7	11	14	16.5	21	25	28	30	35

*Two-gear mechanism, $R = R' = 10$ inches.

Table 3—Permissible Backlash in Gears*

Diametral Pitch	Backlash Normal to Flank (in.)
1	0.025-0.040
2	0.014-0.020
4	0.007-0.011
8	0.004-0.006
16	0.002-0.004
32	0.002-0.004

*AGMA, 1943.

Table 4—Multiple Gear Trains with 0.1 Eccentricity

	Number of Gears in Line				
	2	3	4	5	6
i_{max}	1.22	1.488	1.814	2.212	2.700
i_{min}	0.82	0.672	0.551	0.452	0.370
n	1/1.5	1/2.25	1/3.37	1/5.05	1/7.58

be obtained. If, after consideration of the influencing factors, a mechanism with fixed centers is selected as later discussed, the center distance is given by

$$C = 2R + H = 2R\,(1 + h) = 2R\left(1 + \frac{E^2}{2}\right) \quad (26)$$

For instance, in a recent application of elliptical gears, *Fig.* 10 gives for $i_{max} = 1.35$ and $i_{min} = 0.75$ a value $E = r/R = 0.15$ and $h = 2.25$ mm $= 0.09$ inch. For gears with 73 teeth and diametral pitch of 14, as suggested, a pitch circle radius of $R = 73/2.14 = 2.607$ inches is obtained. This gives an actual eccentricity of $r = 0.15\ (2.607) = 0.391$-inches and a stroke of $H = 2.25\ (2.607)/100 = 0.0587$-inch. If ordinary involute teeth are used, an addendum of 0.0715-inch and a dedendum of 0.0827-inch result. That is, the actual movement in the flanks is smaller than the height of teeth, so that no obvious danger exists between 159 to 168 deg. The center distance should be $x = 2(2.607) + 0.0587 = 5.273$ inches. The greatest clearance between the teeth of mating gears will occur for $p = 90$ and 270 deg, that is, when the centers of gears are on the center line. This factor facilitates correct adjustment of the mechanism. To reduce the influence of the variation of the center distance, a smaller diametral pitch, for instance 10 or 9, might be selected in this case, resulting in higher teeth. It may be mentioned, however, that simultaneously with smaller pitch the range of adjustment is reduced.

For the practical application of this mechanism the following two possibilities exist:

1. For small eccentricities to about $E = 0.1$ or 0.15, a mechanism with fixed centers can be used, eliminating the sliding piece, sliding slot in the base and connecting rod.
2. For any larger eccentricities, the mechanism as shown in *Fig.* 3 is used, but distinct parts such as the connecting rod can be eliminated because of the very small stroke of the mechanism, and probably replaced by a spring behind the slide.

To transmit the small rocking movement to a stationary driven shaft a coupling of the Oldham type can be used. Whereas for mechanisms under the second class even higher eccentricities can be used as indicated in *Fig.* 10 and TABLE 2, the variations in angular velocity of the mechanisms according to the first class are obviously extremely limited.

Therefore, the author has tried to explore the possibility of using multiple and revertible gear mechanisms of the first type with fixed centers and this has led to quite interesting solutions. Using multiple gear trains as planetary gear drives has opened still wider possibilities of obtaining cyclical variations of angular velocities which will be discussed in subsequent paragraphs. In *Fig.* 11 the possibilities for eccentric gear mechanisms of the second type with one fixed and one rocking axis are demonstrated. Mechanisms of the first type with two fixed axes need some further analysis to show that they are built on sound principles.

Two Fixed Axes: The maximum permissible eccen-

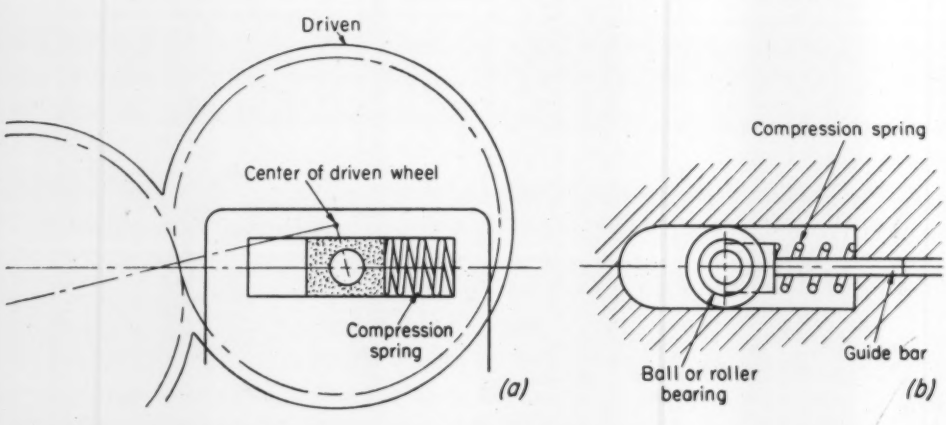


Fig. 11—Design possibilities for mechanisms with larger eccentricities: *(a)* slide and spring, *(b)* roller and spring. In both cases the connecting rod has been omitted

tricity in the case of gears with fixed axes is evidently limited by the permissible pitch line errors and backlash. If one assumes that the gears are meshing without clearance in the position of maximum stroke of the mechanism and give the maximum permissible clearance in those of minimum stroke, this limit can be fixed for a given gear tooth profile.

Assuming a straight-line profile for the basic rack with a pressure angle of α_0, *Fig.* 12, a radial dislocation H of wheel centers gives a tangential clearance

$$c = H \tan \alpha_0 \quad \ldots\ldots (27)$$

and a flank clearance of

$$c_f = H \sin \alpha_0 \quad \ldots\ldots (28)$$

Now c and c_f remain small for a small pressure angle; therefore, for these gears the hitherto used small pressure angle of $\alpha_0 = 14\frac{1}{2}$ deg will be more satisfactory than the recently standardized pressure angle of $\alpha_0 = 20$ deg. The corresponding values are

	14½ deg	20 deg
c/H	0.259	0.364
c_f/H	0.25	0.342

In the case of $D = 20$ inches and $E = 0.1$, from TABLE 2, $H = 0.1$ inch. Therefore, the tangential clearance can be at maximum for a 14½ deg gear: $c = 0.1\,(0.259) = 0.0259$-inch and the flank clearance $c_f = 0.1(0.25) = 0.025$-inch. For a 20-deg pressure angle these values are increased to 0.364 and 0.0342, respectively. In such relatively big gears these values seem to be permissible. If, however, such values could not be accepted for very precise gears and those which have to run absolutely smoothly at high speed, a reduction to $E = 0.05$ is recommended, reducing the foregoing values to ¼ that is, to $c = 0.0065$-inch and $c_f = 0.0062$-inch for 14½-deg pressure angle.

ECCENTRIC GEAR MECHANISMS

Since Equations 27 and 28 have been derived from the rack profile they are bound to give only approximate results. A more accurate result may be obtained by application of the involute geometry. The flank clearance for involute gears without correction can be expressed by

$$c_f' = (R_1 + R_2) \cos \alpha_0 \,(\text{inv } \alpha - \text{inv } \alpha_0) \quad \ldots\ldots (29)$$

where R_1 and R_2 are pitch radii, α_0 = pressure angle of the assumed rack, and α the pressure angle at the contact point. Between α_0 and α the following relationship exists:

$$\cos \alpha = \frac{C_0}{C_r} \cos \alpha_0 \quad \ldots\ldots (30)$$

where C_0 = center distance for $c_f = 0$ and C_r = center distance for clearance c_f'. Inv α is the function, tan $\alpha - \alpha$, as usual.

For the assumed gear with $R_1 = R_2 = 10$ inches, $E = 0.1$, $H = 0.1$-inch, $C_r = 2R + H = C_0 + H$, a pressure angle $\alpha_0 = 14\frac{1}{2}$ deg yields $c_f = 0.0261$-inch and $\alpha_0 = 20$ deg yields $c_f = 0.0526$-inch. The value for $\alpha_0 = 14\frac{1}{2}$ deg corresponds well with the approximate solution.

This theoretical calculation of flank clearance may be combined with practical values of backlash permitted for distinct types of commercial spur gears. Such values have, for instance, been compiled by the American Gear Manufacturers Association, TABLE 3, and they may be applied here in an unorthodox way. Whereas in commercial gears the backlash is considered to be present in each angular position of the gear, in this instance the maximum backlash is as-

Fig. 12—Below—Influence of axial dislocation on gear clearance for 14½ and 20-deg pressure angles (c = tangential clearance and c_f = flank clearance)

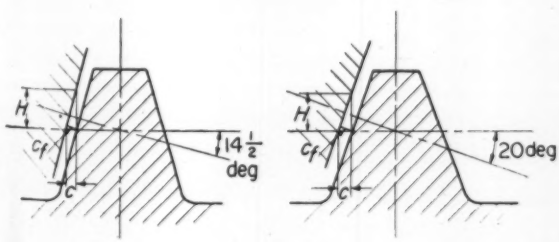
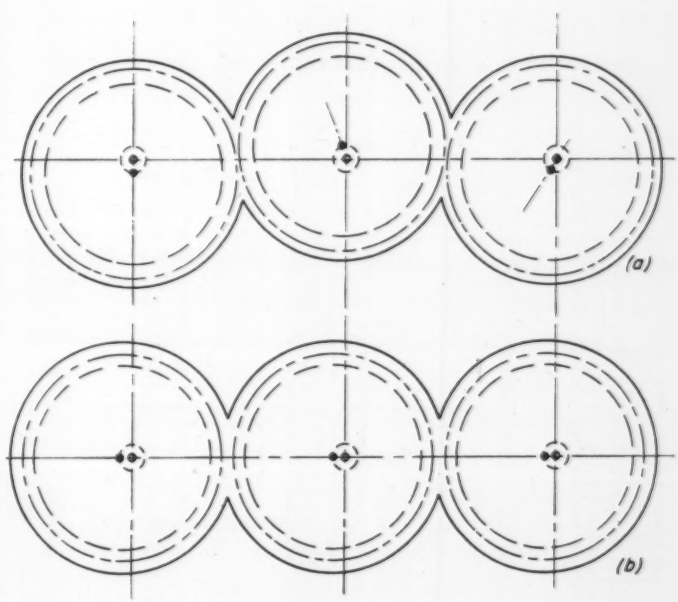


Fig. 13—Right—Triple gear train for eccentricity $E = 0.1$ and pitch diameters of 2 inches. At *a*, initial position for calculation of the mechanism, and *b*, centerline position $p = 270$, $p' = 90$ deg



sumed to be present in only two positions during one full rotation.

For instance, in the foregoing example with $R = 10$ inches, $E = 0.1$, and $H = 0.1$ inch, the involute formula gave a flank clearance of $c_f = 0.0261$-inch for 14½-deg pressure angle. In TABLE 3 this clearance conforms to $P_d = 1$, and the number of teeth is found directly to be $t = 2RP_d = 20(1) = 20$. If the gears are provided with 20 teeth each, the maximum backlash will be that according to the American Standard.

Instead of spur gears with straight teeth, helical gears may prove more useful for this purpose, since more teeth are in mesh simultaneously and a smoother working of the mechanism may result.

From the geometry of the mechanism, it is possible to calculate the jamming positions as well as the positions of maximum clearance. It was found that the maximum clearance will be present at points of minimum stroke of the basic mechanism, that is, when the fixed centers and the gear centers lie in line. The resulting two positions may favorably be used as setting positions when assembling the mechanism instead of the angles $p = 0$ deg and a_0 on which the original calculation was based. Since in this position the maximum backlash will be present, one can obtain a correct picture of possible clearance.

In the model, *Fig.* 13*a* and *b*, ordinary commercial spur wheels were used and when assembled according to the given rules, the mechanism worked without jamming. If, however, only the position of a single tooth is changed, jamming occurs in a certain position. Another model mechanism was built, also from commercial gears, which evidently had cycloidal teeth, probably the poorest profile for use with varying center distance. Actually a satisfactory operating reverting gear mechanism with four gears was obtained.

Multiple Gears for Fixed Centers: Since for fixed centers the eccentricity is limited, a multiple gear train gives the possibility of obtaining higher total velocity ratios n because the variations multiply. It is, therefore, possible to arrange, for instance, several gears in line with their actual rotating centers displaced by a uniform amount. No difficulties were found in using eccentricities of $E = 0.1$ to 0.15 which could be verified on an adjustable mechanism. The multiple gear train can be considered as the coupling of two gear trains, whereby one gear belongs actually to two mechanisms, thus constituting some saving in material and labor. As mentioned before, the maximum and minimum velocity ratios as well as the total velocity ratio are multiplied as shown in TABLE 4.

The centers of the wheels have to be arranged in line as shown in *Fig.* 13 and the center distances have to correspond to the previously given values. The ar-

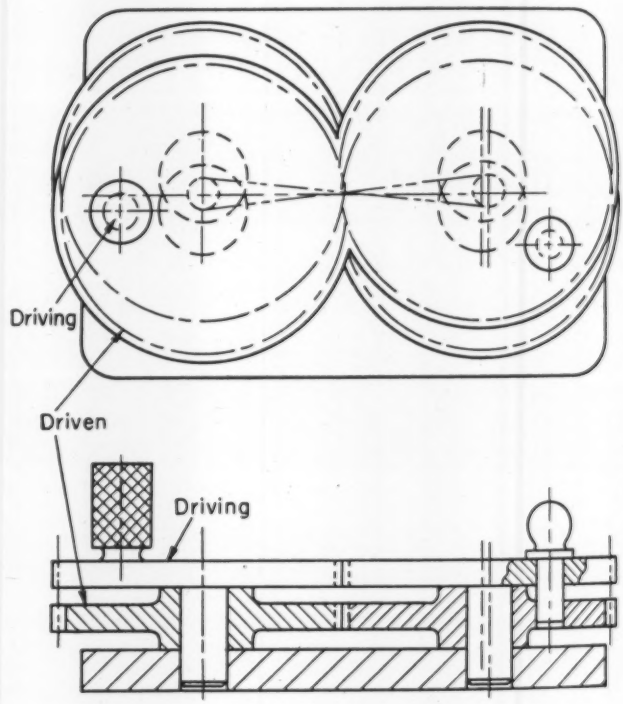


Fig. 14—Above—Reverting gear train composed of four gears, equivalent to gear train in *Fig.* 13

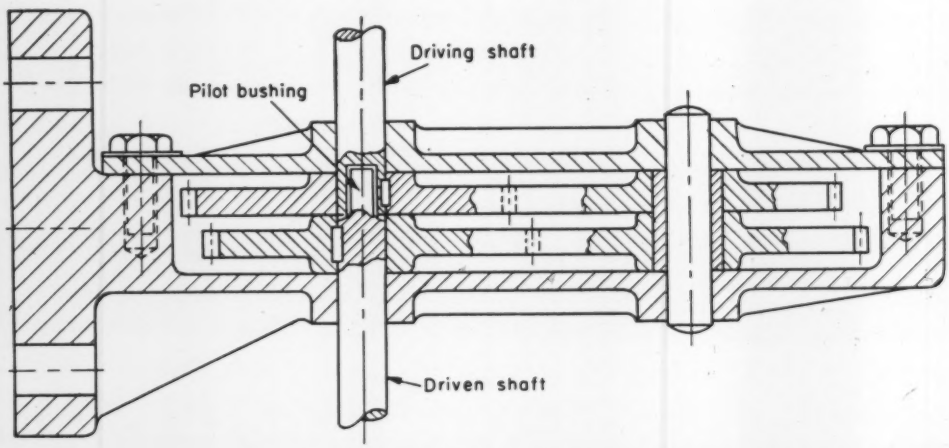


Fig. 15 — Left — Reverting gear train enclosed in gear box

rangement of the gears in line may lead to large mechanisms, since driving and driven shafts are separated by a distance $2(n\text{-}1)R$ with n number of gears employed. A better solution, therefore, is a reverting gear train, *Fig.* 14. This is in the form of an operating model containing two gear trains, and having kinematically the same performance as the three-gear train, *Fig.* 13. Whereas actually the eccentricities of the gear sets need not be the same (for instance, one gear set may have an eccentricity $E = 0$), the eccentric axes of the two coupled gears have to be at an angle of 180 deg. The advantage of this gear is that it can be easily enclosed in a gear box, *Fig.* 15, with each spindle running in double bearings. Furthermore, instead of having only two axes, such a mechanism can embody three or even more axes (see TABLE 4). Actually with only the expense of an additional gear wheel a much better arrangement is obtained.

If the eccentric axes in the mechanism do not enclose an angle of 180 deg, any arbitrary arrangement between driving and driven axes can be obtained, independent of the size of the gears applied, as shown schematically in *Fig.* 16 for a set of three two-gear mechanisms.

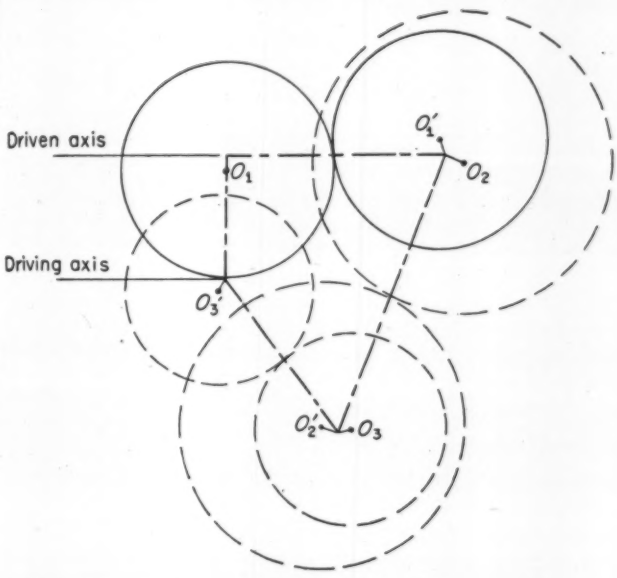
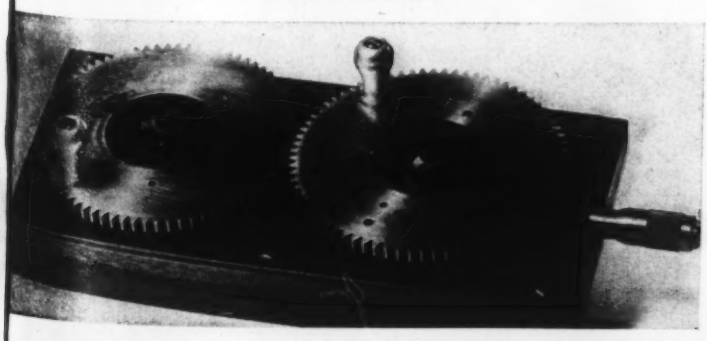


Fig. 16—Above—Arrangement of three gear trains in an arbitrary manner, to obtain a given center distance

Fig. 17—Below—Photograph of experimental mechanism which permits varying eccentricity and center distance



Practical Investigation: While the correctness of the mathematical deductions was first only checked by a few simple operating models made from ordinary commercial spur gears, recently a special mechanism, *Fig.* 17, was made for both variable eccentricities and center distances. The size of the mechanism was large enough for actual measurements, which consisted in finding the correct co-ordination between eccentricity and center distance to produce easy rotation of the wheels without jamming.

The test mechanism, *Fig.* 18, consists of the two spur gears R and R', each provided with a radial slot s and s' in which blocks t and t' carry cylindrical trunnions. Block t fits into a bearing block b fixed in the base a, whereas t' fits into a block b' sliding in the base and connected with a micrometer screw m. Thus the displacement of this block from the zero position, when the gears are centrally pivoted and mesh at the correct center distance $2R$, can be checked. The slots s and s' are provided with marking lines for each 0.025-inch and the blocks t and t' with a center mark, thus allowing correct adjustment. The adjustment shown in *Fig.* 17 is for an eccentricity of 0.1-inch. Each wheel is provided with an operating handle to judge the working of the mechanism. The wheels have $t = 76$ teeth and are of 20 diametral pitch. The pressure angle is 20 deg, which as discussed before is actually a disadvantage in this application. The correct center distance is equal to the pitch diameter. That is, $76/20 = 3.8$ inches. The micrometer screw was so fixed that it gave zero reading for this distance. The mechanism was adjusted for various eccentricities

Fig. 18—Experimental eccentric gear mechanism with adjustable eccentricities and adjustable center distance

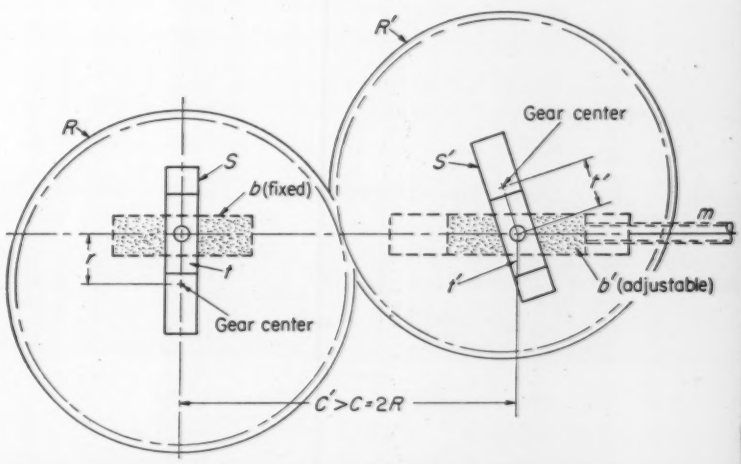


Table 5—Experimental Adjustments of Mechanism

r (in.)	E	Meas. Δ' (in.)	E^2	RE^2 (in.)	$e=\Delta'-RE^2$ (in.)
0	0	0	0	0	0
0.20	0.105	0.0215	0.011	0.0209	0.0006
0.25	0.131	0.0310	0.0172	0.0326	−0.0016
0.30	0.158	0.0450	0.0250	0.0475	−0.0025
0.35	0.184	0.0640	0.0339	0.0645	−0.005(?)
0.375	0.197	0.0705	0.0388	0.0735	−0.0030
0.40	0.210	0.0810	0.0441	0.0840	−0.0030

E of the two blocks and the adjustment of the micrometer screw from zero determined on which eccentricity the mechanism was still free to perform complete revolutions. These measurements are given in the first three columns of TABLE 5.

The center distance of the gears required by the eccentric mechanisms has been given by Equation 26. The value Δ in TABLE 5 is the center distance variation, that is

$$\Delta = C' - 2R \quad (31)$$

According to Equation 26 this should be theoretically

$$e = \Delta' - RE^2 \quad (32)$$

Factor e, calculated in the last column of TABLE 5, yields variable values between 0.0006 to 0.0030-inch which, of course, may contain some experimental errors. The small size of these values seems to indicate that Equation 26 used for actual mechanism is basically sound.

The maximum eccentricity up to which the mechanism can be used is obviously given by the fact that in one particular position the gear teeth would come out of mesh. The height of teeth of involute form is $2.157/P_d = 2.157/20 = 0.108$-inch. This should be equal to the maximum variation of the center distance, or $2.157/P_d = 0.108$ inch $= RE_m^2$. From this, $E_m = 0.238$-inch. The actual mechanism could only be adjusted up to 0.210-inch after which the teeth came out of mesh. This shows that the foregoing criterion is also useful.

This particular mechanism is, however, not considered useful above a limit of $E<0.2$, exceeding the conservative value of $E = 0.1$ hitherto applied by the author. Based on experience with this mechanism, values of $E = 0.15$ to 0.20 seem to be permissible for mechanisms with fixed axes.

The experimental mechanism, *Fig.* 17, can also be adapted to operate with a compression spring, *Fig.* 11. That is, bearing block b can be made to slide in the base under the pressure of a spring. Automatically, backlash between the teeth is taken up. No limits with regard to eccentricity were observed.

Hydraulic Press Utilizes Both Ends of Stroke

A DOUBLE-END press developed by Clearing Machine Corp. produces in each direction of stroke. Used for drawing cartridge cases to a final length of 24 inches, the press thus makes full use of an unusually long stroke, reducing lost time during the "dead" part of the cycle. Low silhouette of the hydraulic press makes the operating mechanism readily accessible. Foundation pits are not necessary, since the press can be bolted to the factory floor. Three 75-horsepower motors are required, a reduction in total power under that required for two separate presses. Capacity is adjustable on each side from zero to 330 tons. Automatic chute feeds are pneumatically and electrically interlocked with the press.

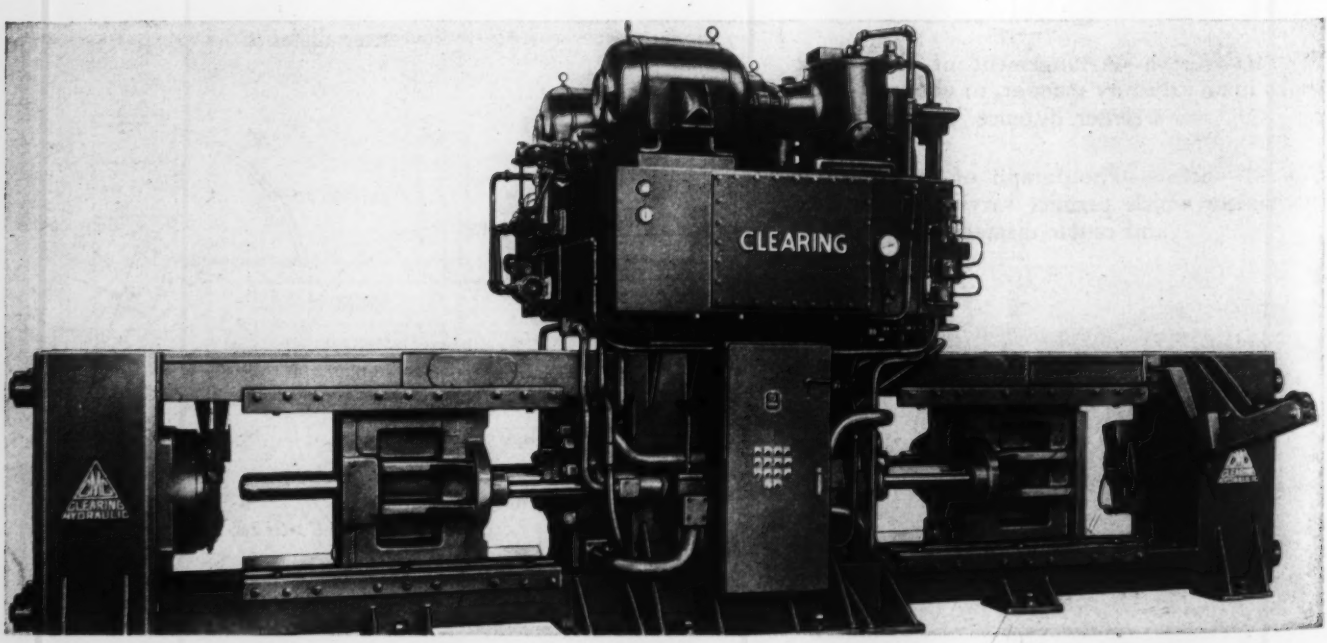


Fig. 1 — Cold - dished of Hastelloy F, a new corrosion-resistant alloy, this top dollar-plate is for rigorous service in a sulphite digester

Corrosion-Resistant Alloy

. . . combines heat and corrosion resistance with workability

A NEW alloy has been developed as an intermediate in corrosion resistance, workability and cost between the austenitic stainless steels and the nickel-molybdenum alloys, *Fig.* 1. A complex nickel-chromium-molybdenum-iron alloy, recently developed Hastelloy F is essentially a compromise in corrosion resistance; it has many of the properties of austenitic stainless in resisting strong oxidizing conditions, yet has ability to withstand reducing solutions, TABLE 1. Resistance to pitting and stress corrosion seems to be high, according to preliminary tests, and the metal resists both acid and alkaline solutions.

Although few major applications have been tested for the Haynes-Stellite Co. metal, one stands out particularly. The nickel-base alloy has been used for more than three years in the top vapor zone of a sulphite digester, in which the cooking liquor contains about 10

Table 1—Corrosion Resistance of Hastelloy F

Sulphuric Acid: Hastelloy F has excellent resistance to boiling 10 per cent solutions of sulphuric acid. It has good resistance to air-free sulphuric acid in concentrations up to 30 per cent and at temperatures up to 176 F. The high chromium content increases its passivity when air or oxidizers are present in the acid. It is not recommended for use in boiling sulphuric acid in concentrations above 20 per cent.

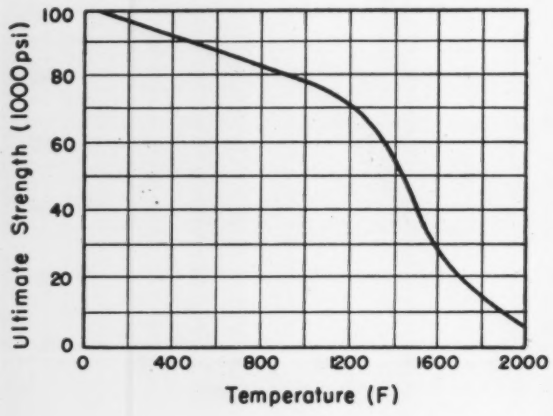
Phosphoric Acid: 70 per cent concentrations of this acid, at the boiling point, can be handled successfully. Boiling 85 per cent concentrations, however, will corrode the new alloy rapidly. Corrosion rates will, of course, be affected when dissolved copper or other metallic ions that inhibit the action of the acid are present.

5% Ferric Chloride plus 10% Sodium Chloride: Hastelloy alloy F has good resistance to pitting in this solution, even though the solution tends to pit chromium bearing alloys.

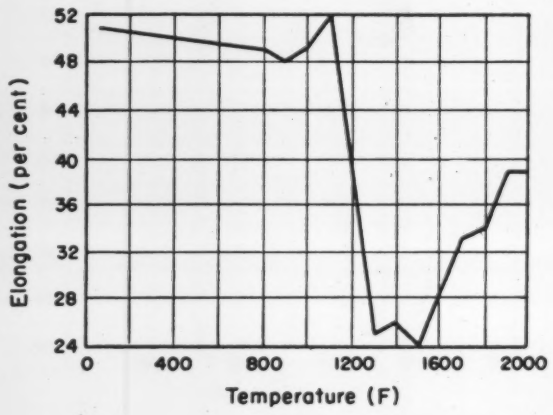
42% Magnesium Chloride: This solution is frequently used to determine the susceptibility of 18-8 stainless steel to stress corrosion. Specimens of Hastelloy F were exposed to a 42 per cent solution of magnesium chloride at the boiling point. Stresses equal to the yield strength of the alloy were applied. No cracking occurred after 500 hours' exposure. This fact is of particular interest since the combination of stress and exposure to certain aqueous acid chloride solutions will cause cracking in austenitic alloys that depend upon passivity for their corrosion resistance.

Nitric Acid: Hastelloy F tends to exhibit an ascending corrosion rate with time when exposed to boiling 65 per cent nitric acid.

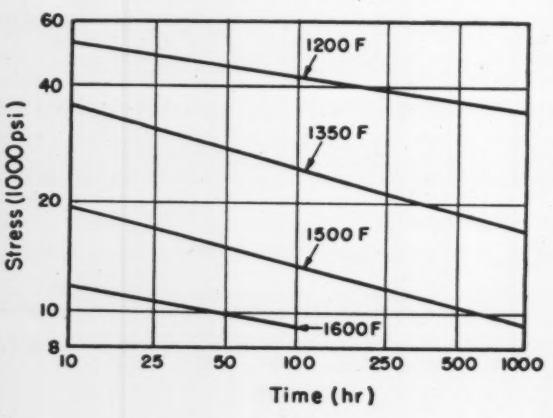
Sea Water: Samples of alloy F have been exposed to sea water for a period of 25 months. These were examined at intervals of 6, 13 and 25 months. The results showed that the alloy has good resistance to pitting. After 6 months the alloy was relatively free from pitting. However, it was found susceptible to undergasket corrosion. At the expiration of 25 months, no further pitting had taken place, and the original pits had not enlarged significantly. Equipment for use in sea water should be designed to minimize crevices and contact areas that can form regions of low oxygen concentration.



(a)



(b)



(c)

Fig. 2—Excellent tensile strength at high temperatures is characteristic of the new alloy, *a*. Low ductility in the 1300-1600 F range, *b*, precludes hot forging at these temperatures, although hot work ability is good at other temperatures. Stress to rupture for sheet, solution annealed at 2125 F and air cooled, is shown at *c* for the new material

per cent sulphur dioxide, and has been entirely satisfactory under these severe pitting conditions. Tests so far indicate that Hastelloy F has an excellent combination of properties for processes involving: (1) weak, strong or sulphurous acids for the first part of the cycle and an alkaline condition for the final part, starting with pH 4 or lower and ending with about pH 9; (2) liquid or vapor phases of alkaline and acid pulping digesters, in which corrosion amounts to less than 0.001-inch per year for the new alloy, but has been especially serious in the vapor phase for other alloys.

Hastelloy F is stronger and about as tough as the austenitic stainless steels, TABLE 2. It is ductile enough for intricate cold-forming but requires more power to deform than austenitic stainless.

Table 2—Composition and Properties of Hastelloy F

21.0-23.0 Cr, 44.0-47 Ni, 5.5-7.5 Mo, 1.75-2.5 Cb plus Ta, 0.50 Ta min, 0.08 C min, 1.0-2.0 Mn, 0.04 P max, 1.0 Si max, 1.0 W max, 2.50 Co max, 0.15 Cu, 0.03 S, balance Fe

Property	Sheet (0.065-in.) Longitudinal	Sheet (0.065-in.) Transverse	Bar Stock (1 in. diam)
Tensile strength (1000 psi)	106	106	108-116
Yield strength, 0.2% offset (1000 psi)	50.9	49	48-53
Elongation in 2 in. (%)	52	52	40-46
Reduction of area (%)	..	..	47-54
Izod impact* (ft-lb)	..	..	58-100
Hardness (Rockwell B)	84	..	89-93
(Brinell)	..	..	160-180 Bhn
Density (gm/cu cm)			8.2
Electrical resistivity (microhm/cm)			112
Magnetic permeability at 116 oersteds			1.2
Modulus of elasticity (psi)			29×10^6
Coefficient of thermal expansion (in./in./deg F)			
68-200 F			8.1×10^{-6}
68-600 F			8.7×10^{-6}
68-1000 F			8.9×10^{-6}
68-1400 F			9.5×10^{-6}
68-1800 F			10.2×10^{-6}

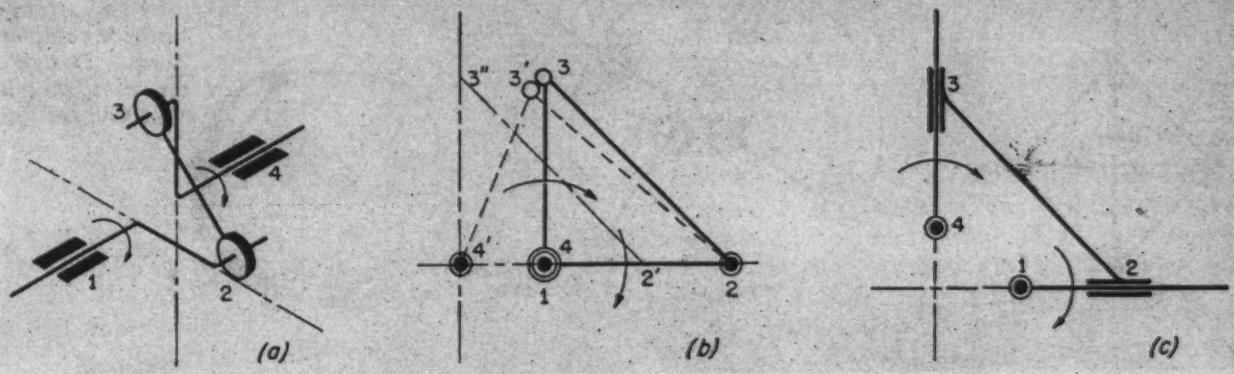
*Notched specimens at room temperature. No loss of toughness shown by additional tests at —58 F.

High-temperature properties are also favorable, *Fig.* 2. Strength of the alloy does not change significantly after furnace cooling from temperatures in the 1000 to 2000 F range. Some ductility is lost in cooling slowly from the 1600 to 2000 F range. Ductility is lowest between 1300 and 1600 F and severe hot-forming operations are not possible in this range.

Metallurgical characteristics of the alloy are suited for resistance welding, although it can be welded by the metallic-arc, inert-gas or shielded-arc methods. Welds made by the metallic-arc and inert-gas shielded arc methods are ductile and have mechanical properties comparable to the base metal.

"If a little knowledge is dangerous, where is the man who has so much as to be out of danger?"—THOMAS HENRY HUXLEY.

Fig. 1—Schematics *a* and *b* show the requirements for the orthodromic connection of shafts 1 and 4. Direct though unsymmetrical solution is shown at *c*



ANGLE-TRUE MOTION

. . . provided by orthodromic mechanisms for connecting parallel shafts in precision applications

By Michael Daniloff

Equipment Engineering Div.
Raytheon Mfg. Co.
Newton, Mass.

CONNECTION of two parallel shafts is termed *orthodromic* if the movement of one shaft is an exact duplication of the movement of the other. Used here for the first time, *orthodromic* is derived from the Greek and literally means straight or correct running.

Orthodromic connections are important in analog mechanical computers, as well as in other fields of machine design, because in practice location of shafts in the frames of such mechanisms with the extremely high accuracy required is extremely difficult. Binding, springing and excessive friction are experienced under certain conditions. A mechanism which is able to transmit an angle-true or orthodromic motion between two parallel shafts, so located that the distance between them can vary somewhat, is of considerable value. This problem, like many in kinematics, can be solved by the judicious employment of sliding surfaces, rolling surfaces and linkages. Examples of all three types of solutions are known and used more or less widely.

Such mechanisms can be built up either by "logical" or "numerical" synthesis. Numerical synthesis of mechanisms constitutes a branch of the science of kinematics developed in Germany, principally in the years following the close of World War I. The name itself was coined by R. Beyer in 1931. The aim of this rather recent scientific discipline is to construct, by means of purely analytical operations, mechanisms which are to fulfill certain prescribed conditions. It soon becomes apparent, however, that the numerical synthesis of mechanisms has been really over-publicized, and that this branch of kinematics, by its very essence, is far from being able to perform all the

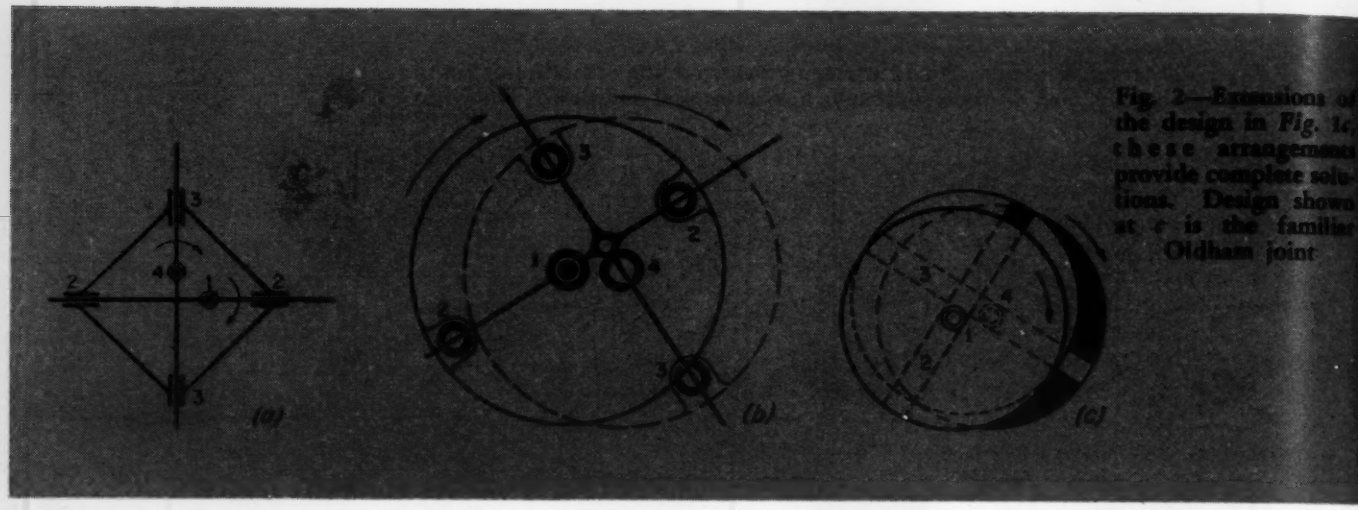


Fig. 2—Expansions of the design in *Fig.* 1*c*, these arrangements provide complete solutions. Design shown at *c* is the familiar Oldham joint

functions which were at one time expected of it.

In fact, numerous instances appeared in which highly ingenious and complicated mechanisms were apparently developed by purely synthetic methods, only to prove incapable of motion when actually built in model form. The method fails to provide an answer to all the conditions which may be imposed upon a mechanism. The value of the basic equations of numerical synthesis is not lessened thereby, if they are considered as conditions necessary but not sufficient. If the basic equations of numerical synthesis indicate that a given mechanism is not capable of motion, it certainly will not be capable of it when built. However, it does not follow that if a mechanism has been given a clean bill of health in the light of the equations of numerical synthesis, it will be even capable of motion.

This article discusses orthodromic mechanisms which have been developed principally by the logical process, although to be sure, numerical synthesis has been used at certain stages.

Basically the problem of orthodromic motion consists in requiring crank 2, *Fig.* 1*a*, of shaft 1 to make a constant angle with crank 3 of shaft 4 (an angle of 90 degrees, for example), when one of the shafts is rotated, such as input shaft[1]. In other words, a mechanism is to be so designed that the two cranks are always at right angles to each other, no matter through what angle one of the shafts has been rotated and irrespective of the distance between shafts 1 and 4 measured in a plane normal to their axes. Of course, if shaft 4 moves to position 4′, the angle between cranks 1-2 and 4-3 will no longer be 90 deg. To preserve this angle, link 2-3 must move parallel to itself to a new position such as 2′-3″, *Fig.* 1*b*. This remark in turn suggests immediately the solution shown in *Fig.* 1*c*. No matter what the relative positions of center lines 1 and 4 of the two shafts may be, link 2-3 will move parallel to itself and, consequently, the angle between the cranks will always be maintained at the required value of 90 deg.

Since the design shown in *Fig.* 1*c* lacks symmetry, the next logical step is to make it symmetrical, which leads to complete solutions shown in *Fig.* 2*a* and *b*. These mechanisms are mutually reciprocal kinematically in the sense that the kinematic pair consisting of the crank and the frame has been inverted. The rectangular frame in *Fig.* 2*a* has become the cross-shaped element of *Fig.* 2*b*. If, instead of a cross-shaped piece as in *Fig.* 2*b*, two grooves are cut at right angles in an intermediate circular piece, the familiar Oldham joint is obtained, *Fig.* 2*c*. It has been proved, incidentally, that an Oldham joint will transmit angle-true rotation between parallel shafts—a result known, of course, for a long time.

In *Fig.* 2*b*, the essence of the mechanism resides in the fact that cross 2-2—3-3 is guided along two mutually perpendicular directions. This fact suggests the next step in the logical development of the mechanism—the use of Watt's approximate straight-line motion to guide the cross-shaped piece as required, mainly along two directions at right angles to each other. Watt's motion itself is shown in *Fig.* 3*a* and its application to the problem in *Fig.* 3*b*. Watt's linkage consists of ten joints and is in itself, rather complicated, but the complication becomes really extreme in the case of the derived mechanism shown in *Fig.* 3*b*. Containing no fewer than 22 joints, this mechanism was synthesized by Robert Franke who states, however, that when executed as a model, it produced free,

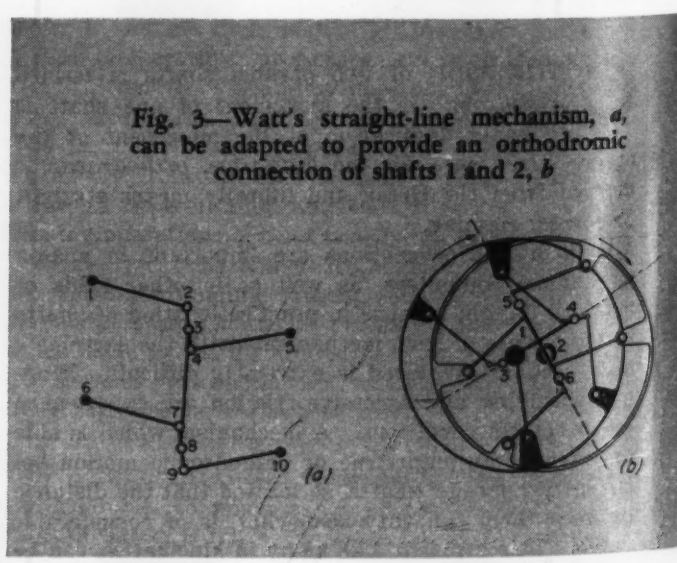


Fig. 3—Watt's straight-line mechanism, *a*, can be adapted to provide an orthodromic connection of shafts 1 and 2, *b*

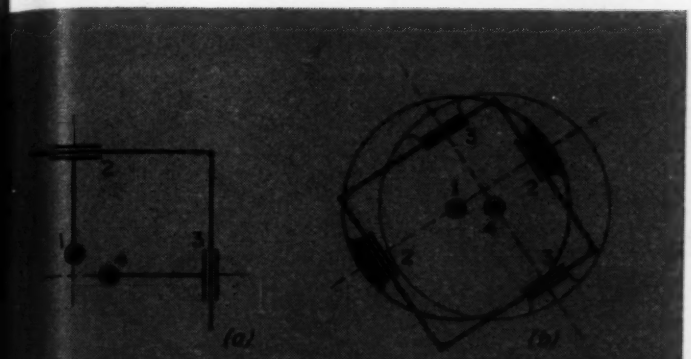


Fig. 4—Design *a* is a kinematic inversion of *Fig. 1c*; *b* is an inversion of *Fig. 2b*

sure and smooth motion.

In logical synthesis, an important part is played by the principle of the inversion of kinematic pairs illustrated by the mechanism in *Fig. 4a* which is the inversion of the mechanism shown in *Fig. 1c*. Likewise, the mechanism shown in *Fig. 4b* represents the inversion of the mechanism shown in *Fig. 2b*. More specifically, the cranks in *Fig. 1c* can slide through bushings made integral with link 2-3, whereas in *Fig. 4a*, the cranks are provided with bushings through which the right-angled member slides. The design is made symmetrical by the employment of a square frame as shown in *Fig. 4b*.

From a higher point of view, the problem considered can be solved in three ways, all kinematically different. These methods are shown in *Fig. 5*. The solution just discussed is represented in *Fig. 5a* and consists in allowing motion of crank 1 to position 1′ and of 2 to position 2′ along directions normal to each other while the link connecting them, 1-2 and 1′-2″, remains parallel to itself. The second possibility consists in having the slides themselves move in two mutually perpendicular directions, *Fig. 5b*. Slide 1 moves parallel to itself from position 1 to position 1′ in a direction normal to its original longitudinal axis, while slide 2 moves normal to its direction and parallel to itself from position 2 to position 2′. The third possibility is illustrated by *Fig. 5c*, in which crank 2 moves to position 2′ along the direction of the first guide, whereas the second guide 1 moves parallel to itself and normally to the direction of the first guide to new position 1′. In all three cases, the link corresponding to member 2-3 of *Fig. 1a* remains parallel to itself through the provision of suitable degrees of freedom, thus ensuring an orthodromic connection. In this way, the original angle between the cranks is preserved, despite the relative motion of the centers of the shafts on which these cranks are mounted. The schematic solution shown in *Fig. 6* results immediately. Frame 6-7 can move parallel to itself, being one side of the parallelogram 5-6-7-3, whereas crank 1 can slide through bushing 2 along its own direction.

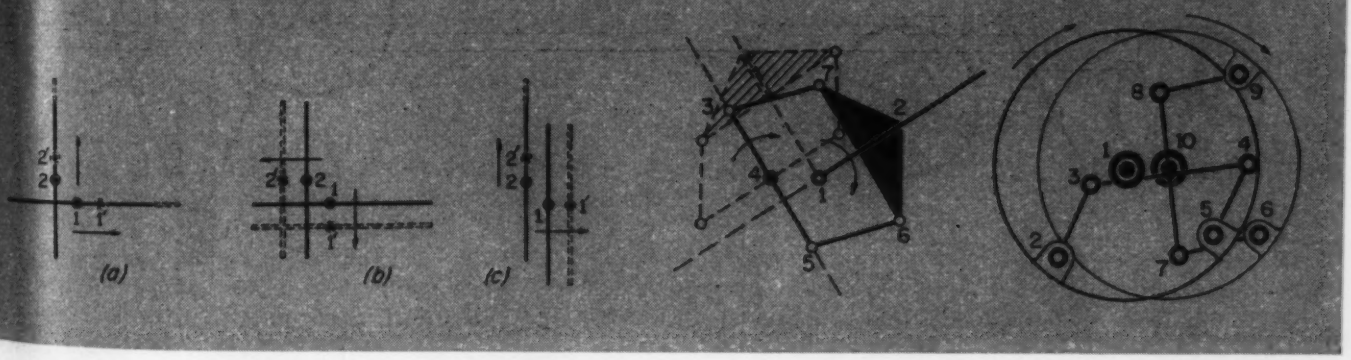
Since a solution of the problem rests on guiding a cross along two mutually perpendicular directions, a simplification of the design shown in *Fig. 3b* can be obtained by guiding the cross-shaped piece by means of parallel links, *Fig. 7*. Link 2-3 is parallel to link 5-4 and link 8-9 is parallel to link 7-6. The latter design is the Karger gear which is simple and has only seven joints. It has been used for driving the wheels of electric locomotives through gears external to them powered by motors located on the main frame of the locomotive, somewhat along the lines of the Brown-Boveri-Secheron system.

An example of a design developed by numerical synthesis is given in *Fig. 8a*. This mechanism was obtained as the result of a very complicated analytical process by a well-known authority on the subject of numerical synthesis. Robert Franke points out, however, that the mechanism is incapable of motion, because links 3-10 and 4-9 are not parallel to each other, and the same is true of links 5-8 and 6-7. As a result when the two shafts rotate while being out-of-line, *Fig. 8b*, the cross-shaped piece must distort and eventually break. The reason for the failure of numerical synthesis in this case is that the method is not competent to take into account the fact that the cross-

Fig. 5—Orthodromic connections can be obtained by these three kinematically different designs

Fig. 6—Common features of three solutions in *Fig. 5* suggest this parallelogram solution

Fig. 7—Known as the Karger gear, this design is a simplification of *Fig. 3b*



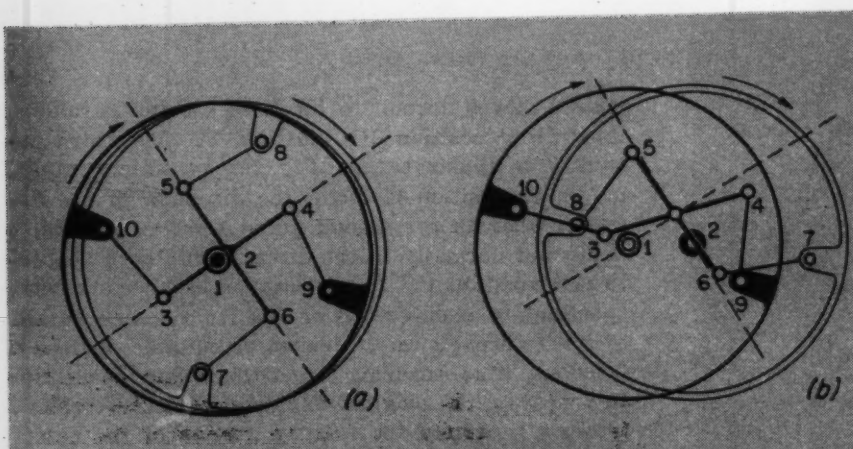


Fig. 8 — Numerical synthesis produced this design which is incapable of motion without damage to parts

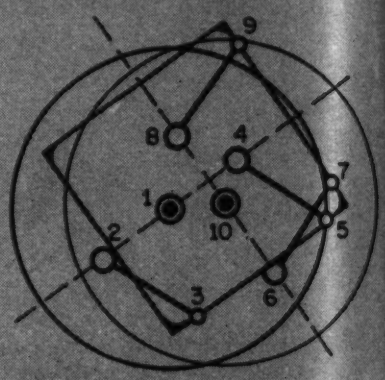


Fig. 9—Use of linkages instead of guides leads to this inversion of *Fig.* 4

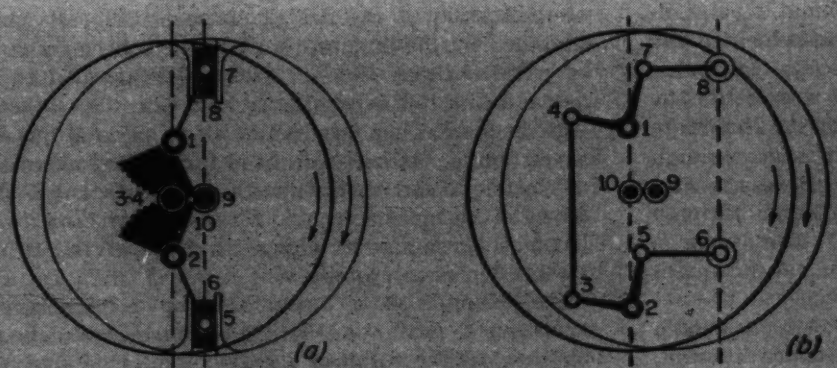


Fig. 10—Derived from *Fig.* 5*c*, mechanism *a* with gears and *b* with links provide orthodromic motion of the two coupled shafts

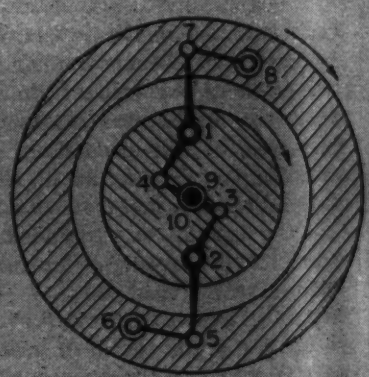


Fig. 11—Misuse of numerical synthesis resulted in this design which, although capable of motion, is not orthodromic

Fig. 12—"Nurnberg" shears provide orthodromic solution for opposite rotation of shafts

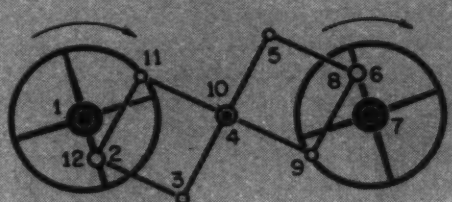
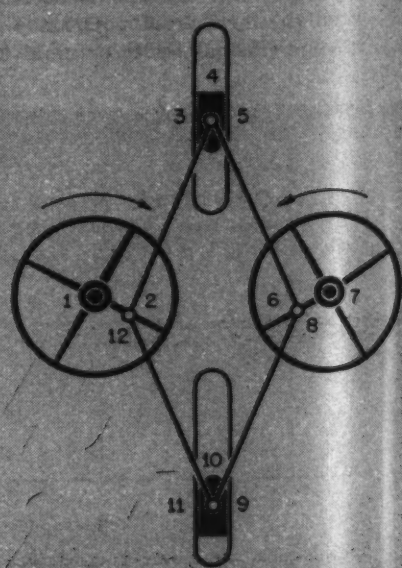


Fig. 13 — Design in *Fig.* 12 was developed from this intermediate solution for which, however, the shafts rotate in opposite directions



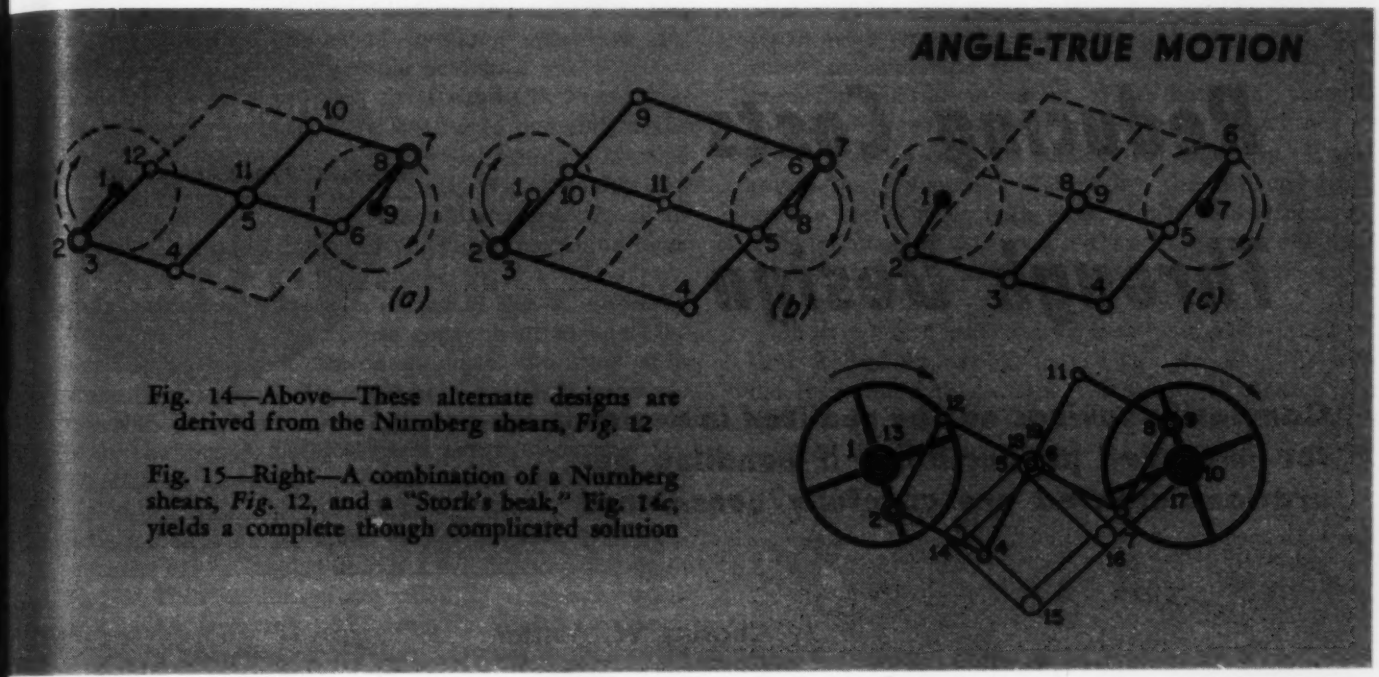


Fig. 14—Above—These alternate designs are derived from the Nurnberg shears, *Fig.* 12

Fig. 15—Right—A combination of a Nurnberg shears, *Fig.* 12, and a "Stork's beak," Fig. 14*c*, yields a complete though complicated solution

shaped piece must be guided along two mutually perpendicular directions, shown by dotted lines in *Fig.* 8*a*.

In the same way in which the kinematic principle shown in *Fig.* 1*c* led to the mechanism shown in *Fig.* 7, a kinematically inverse solution such as shown in *Fig.* 4 can be obtained by employment of linkages instead of guides and leads to the mechanism shown in *Fig.* 9. Here the square frame, instead of sliding through parallel bushings machined in the flanges of the two shafts, is guided along mutually perpendicular directions by links 2-3, 4-5 and 8-9, 7-6.

Solutions which make use of linkages can be designed also with rolling contacts, such as gears or possibly cams, the basic kinematic principle remaining unaltered. In this manner, the mechanism shown in *Fig.* 10*a* is derived from the schematic arrangement shown in *Fig.* 5*c*. The design allows motion of blocks 6 and 8 along the straight line 5-7 while joints 1 and 2 can move in a direction perpendicular to the first, normally to line 5-7. The corresponding solution by means of linkages is shown in *Fig.* 10*b* where the same kind of motion is obtained as in the design shown by *Fig.* 10*a*. Parallel links 5-6 and 7-8 allow joints 6 and 8 to move along dotted line 6-8 while joints 1 and 2 can move in a direction normal to the first because of the presence of link 3-4.

A second example of a faulty design developed by the misuse of numerical synthesis is shown in this connection in *Fig.* 11. This mechanism, even though it is capable of motion, is not orthodromic as pointed out by Franke. This fault is not immediately apparent but can be proved by geometry.

Another problem is the orthodromic kinematic connection of two parallel shafts in which the flow of energy is reversed in direction. That is, energy flows along the first shaft to its flange, is transmitted by angle-true rotation to the flange of the second shaft, and flows away from that flange along the second shaft in a direction opposite to the first. This problem has been completely solved by R. Franke by means of the closed linkage polygon shown in *Fig.* 12 and which bears the name of "Nurnberg shears." This mechanism is a development of an intermediate design shown in *Fig.* 13 which however entails reversal of the direction of rotation. The latter is not of much practical use because the two guides must be located exactly half way between the center lines of the two shafts. In addition, the use of guides in precision applications such as analog computers provides an ample source of manufacturing and other difficulties.

The "Nurnberg shears" ensure an orthodromic kinematic connection between parallel shafts. The scheme can be extended further by completing the parallelogram which results in the designs shown in *Fig.* 14. The design of *Fig.* 14*c* is known as the "Stork's beak." Since all these linkages are closed polygons, the motion is known to be determinate. These examples are instances in which numerical synthesis is not applicable because it gives highly unreliable indications for closed polygons, and model testing provides really the only final answer to the problem.

If the designs shown in *Fig.* 14 are to transmit torque, the middle point, such as 10-4 of *Fig.* 12 must be fixed to the frame at a point located half way between the center lines of shafts 1 and 7. This arrangement can be accomplished by mounting joint 6 of *Fig.* 15 on the apex of a "Stork's beak," *Fig.* 14*c*. Thereby a complete solution of the problem is obtained, albeit a rather complicated one.

BIBLIOGRAPHY

1. Fritz G. Altman—*Zeit. d. Vereins Deutsch. Ing.* 92, 33, 1950, Pages 909-916.
2. R. Beyer—*Technische Kinematik*, Leipzig, 1931.
3. R. Beyer—*"Uber den Zwanglauf raumlicher u. ebener Getriebe," RM-AfG*, 2, 1934.
4. R. Beyer—"Kinematische Paarumkehrung," *RM-AfG*, 3, 1935.
5. R. Franke—*Zeit. d Ver. Deutsch. Ing.* 92, 33, 1950, Pages 897-901.
6. M. Grübler—*Getriebelehre*, Berlin, 1917.
7. R. Kraus—"Zur Zahlsynthese ebener kinematischer Ketten," *RM-AfG*, 3, 1935, Page 707, and 4, 1936, Page 335.
8. R. Kraus—"Aufbaugleichungen und ihre Anwendung auf Getriebe mit einem An- und Abtriebglied," *Mitt. Techn. Inst. Tung-Chi-University*, Woosung, China, II, 9, 1936.
9. R. Kraus—*Getriebetechnik*, 8, 1, 1940 (Communications of the Reuleaux Society).
10. K. Rauh—*Praktische Getriebelehre*, Berlin, 1931.
11. F. Reuleaux—*Kinematics of Mechanisms*, English translation, Macmillan and Company Ltd., London, 1876.

PRODUCTION AND DESIGN

Reducing Costs Through Design

Composite savings can be realized in design for improved producibility if handling operations created are carefully considered

By Charles W. Metter
Manufacturing Engineer
Fischer & Porter Co.
Hatboro, Pa.

IN PRESENT-DAY manufacturing, considerable emphasis is being placed on modern materials handling methods in order to reduce production costs. It is important to remember, however, that a complete materials handling program must start on the drawing board since, in many cases, the need for certain handling operations may be completely eliminated by proper design of the product, by redesign or, possibly, by a completely different process of manufacture.

Since the easiest way to reduce materials handling cost is to completely eliminate the need for moving the material, it is, therefore, vitally important that all the engineering phases in manufacturing be coordinated to eliminate unnecessary steps in production.

Design Consideration: The designer exercises a very complete control over any materials handling within the plant since the actual design of the part controls to a large degree the required production operations. Hence, in this manner, control is exercised over the amount of handling which must be done from one operation to another in manufacture. Many

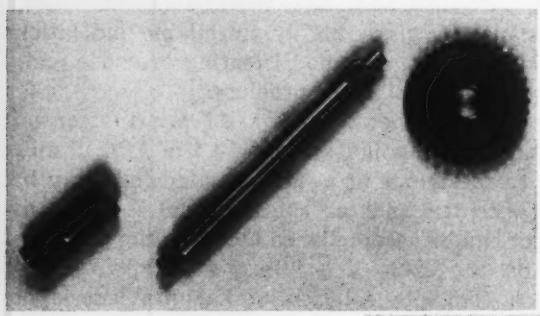
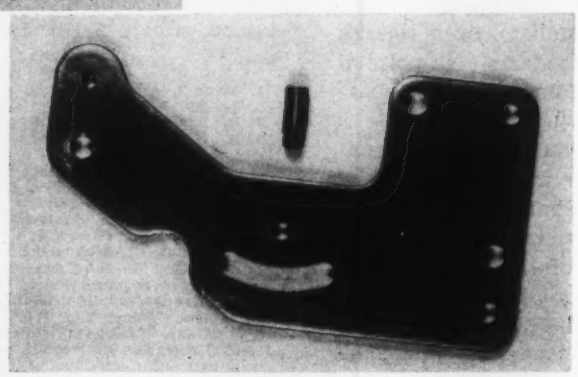


Fig. 1—Above — Knurled sections for press fits eliminated moving these parts to a brazing operation

Fig. 2—Below — Knurled section for press fit eliminated handling these parts to punch press for staking



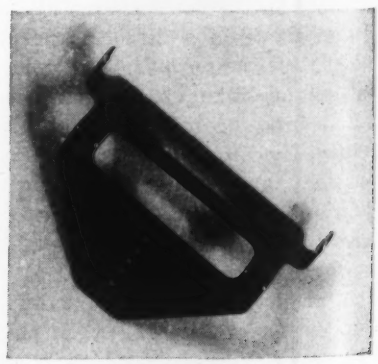


Fig. 3—Above—Reduction in material thickness made punching of holes possible and eliminated handling to drill press

times, the slight or even complete redesign of a part will reduce the number of handling operations required and result in sizeable savings.

The stainless steel gear shaft shown in *Fig.* 1 previously had the brass gear brazed to one end of the shaft, and the hub to the other. By adding a knurled section to each end of this shaft, this assembly can be press fitted together at assembly, completely eliminating handling to the welding department and back to stores.

A controller front plate, shown in *Fig.* 2, originally was sent to the punch press department to have the small bearing shaft staked in place. Addition of a knurl to the end of this stainless steel shaft provided a better fit and also eliminated one handling to and from the punch press department by allowing the parts to be merely pressed together at final assembly.

Reduction in material thickness from $\frac{1}{16}$ to $\frac{1}{32}$-inch thick stock allowed holes to be punched in a progressive die on the stainless steel bracket shown in *Fig.* 3. This eliminated the handling operation to the drill press department necessary on the thicker part.

A more complicated redesign problem is illustrated in *Fig.* 4 where the initial design of the bracket was a two piece assembly. This would have required two handlings in the press department in addition to a trip from stores to welding to spot weld the front piece to the bracket. The change to a one-piece stamping saved handling one piece and eliminated the trip to welding and back. In addition, the die design was simplified by the use of a one piece bracket.

Often, a complete study of a product reveals unnecessary materials handling operations. An interesting example of this type resulted from an original study to eliminate second-operation handling for slotting on a special 8-32 shoulder screw which was used as a stop for the sector gear shown in *Fig.* 5. These parts were originally made on a hand turret type screw machine and then sent to the milling department for a second operation. While discussing possible tooling changes, the question arose as to whether or not this screw could be eliminated completely. It was found that by merely eliminating the two end teeth on the sector gear, both stops would be unnecessary. This eliminated the two different special shoulder screws and all materials handling of these parts through the shop.

Shortly after, the sector gear was redesigned so that it was impossible to use the old die. The new die was made to cut the teeth and eliminated the milling operation. In this case, a redesign of the part reduced handling by combining operations. The sum

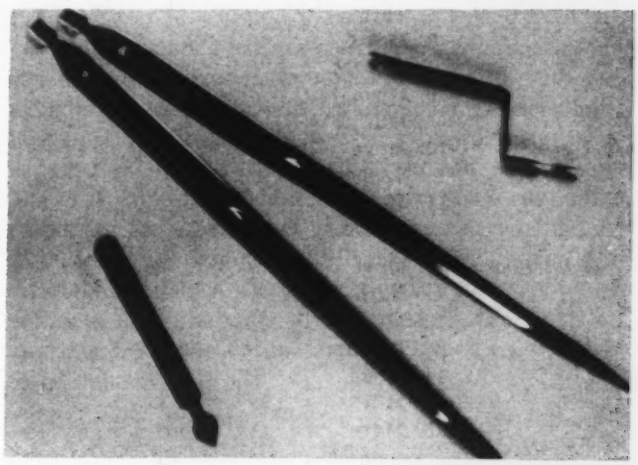


Fig. 6 — Material change to stainless steel eliminated handling to and from plating on these parts

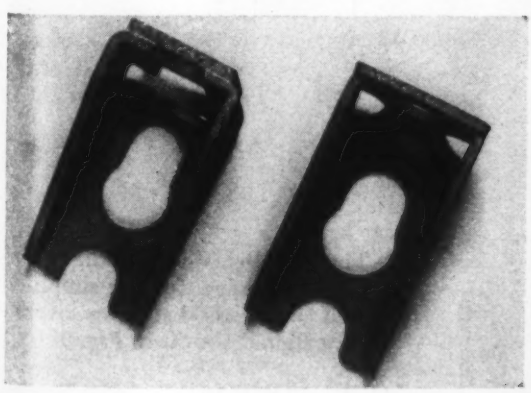


Fig. 5—Below—Redesign of sector gear eliminated two screws and reduced materials handling

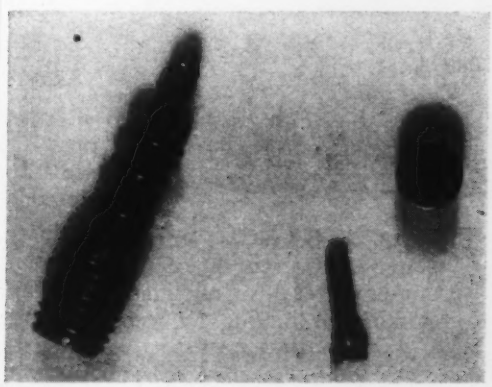


Fig. 4—Above — One-piece bracket design reduced materials handling and welding

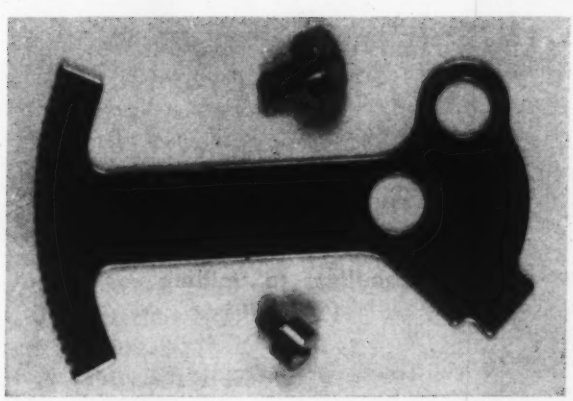


Fig. 7—Above—Change to nickel silver for these parts saved materials handling for plating

total of materials handling savings made possible by these changes in product design is summarized in the following analysis:

	Old Design	New Design
Sector Gear	1. Move Shear Stock	1. Move Shear Stock
	2. Move Punch	2. Move Punch
	3. Move Inspect	3. Move Inspect
	4. Move Mill Teeth	4. Move Stores
	5. Move Inspect	
	6. Move Stores	
Large Screw	7. Move Turn	
	8. Move Inspect	
	9. Move Mill	
	10. Move Inspect	
	11. Move Stores	
Small Screw	12. Move Turn	
	13. Move Inspect	
	14. Move Mill	
	15. Move Inspect	
	16. Move Stores	

In some cases where special shoulder screws are required in small quantities, it has been found desirable to change the type of stock from round to hexagonal so that a milling operation for slotting the head would then be unnecessary. This is only used in those cases where the quantity of parts to be manufactured is too low to be put on an automatic screw machine with a slotting attachment. In this manner, parts may be run efficiently on a hand turret type screw machine and still eliminate the need for any additional handling for slotting.

Another type of design change which often saves materials handling is a change in the type of material from which a part is to be made. All of the pen arms and gage pointers, shown in *Fig.* 6, were originally made from phosphor bronze, and had to be handled twice before they were plated and received back in stores ready for production assembly. These parts were all changed to stainless steel which eliminated the need for plating and the double handling.

Materials handling to and from a plating operation was also eliminated on the parts shown in *Fig.* 7 by using nickel silver. Stainless steel would be too hard to machine for the nozzle shown at left, and would not have been a good material for the pivot bearing and bearing screw shown at right. Hence, the selection of nickel silver.

The counter cover in *Fig.* 8 required additional strength to withstand stresses during shipping. At the same time this strengthening design change was considered, the part was changed from a plated brass design to stainless steel rather than merely to plated steel in order to save materials handling to and from the plating operation.

Different Processes of Manufacturing: Another major consideration in the reduction of materials handling is the possibility of changing from the present manufacturing process to a completely different one.

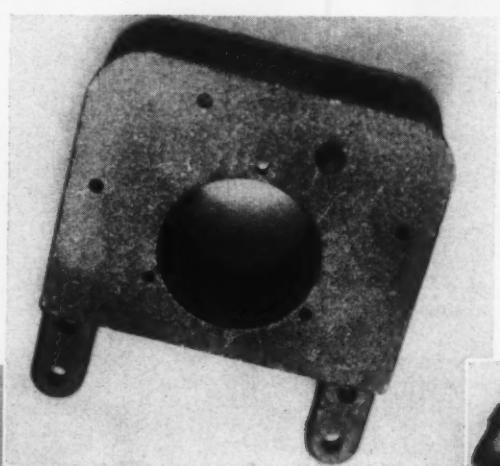


Fig. 8 — Below — Material change for strength of this counter cover also eliminated handling to plating by using stainless steel

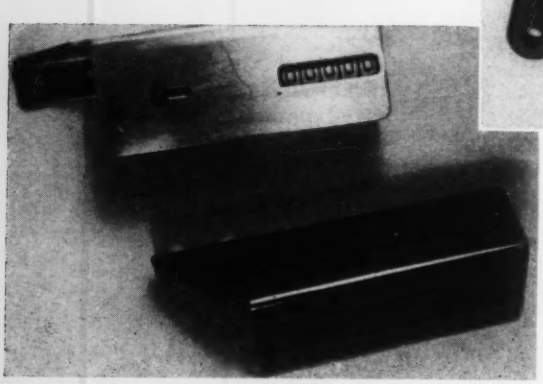


Fig. 9—Above — Precision casting this housing eliminated handling to milling operations

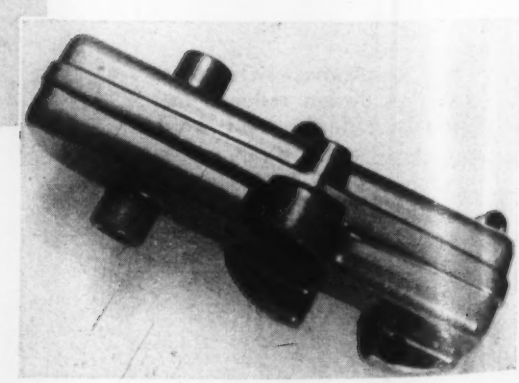


Fig. 10—Below—New die cast housing design further simplified materials handling over original shown in *Fig.* 9

Often, this can be accomplished by changing from a completely machined or fabricated design to an investment casting, or possibly to a die casting. In many cases, this is often the most complicated way of reducing materials handling on the part in question, and for this reason, much more time should be spent completely reviewing the entire product with the possibility that some of the adjacent components may be combined, eliminating handling on such parts.

The proportioner housing, shown in *Fig.* 9 was originally a bronze sand casting. When received in the plant it required two milling operations before the holes were drilled and then tapped. Changing this part from a bronze sand casting to a precision casting completely eliminated the need for moving these parts to the milling department. Finish reaming and tapping operations only were performed before the parts moved to the finishing operations. Investment cast hubs are also shown.

By further redesign, however, it was found that the part could be more economically manufactured by die casting, as shown in *Fig.* 10. A review of the entire assembly also indicated that the two shaft bearing hubs could be combined with the housing. This represented a considerable savings in materials handling since the hubs previously required transportation to and from turning and drilling operations. The following materials handling analysis of the progressive improvement in manufacturing methods and subsequent reduction in handling indicates the savings realized by change of manufacturing process:

	Sand Cast	Investment Cast	Die Cast
Housing	1. Move Mill	1. Move Tap	1. Move Tap
	2. Move Inspect	2. Move Inspect	2. Move Inspect
	3. Move Drill	3. Move Stores	3. Move Stores
	4. Move Inspect		
	5. Move Stores		
2 *Hubs*	6. Move Turn	4. Move Turn	
	7. Move Inspect	5. Move Inspect	
	8. Move Drill	6. Move Drill	
	9. Move Inspect	7. Move Inspect	
	10. Move Stores	8. Move Stores	

Changing an aluminum door, *Fig.* 11, from a permanent-mold casting to a diecasting eliminated drilling 18 small holes. These had previously required handling to a second drilling operation on a small radial drill press.

The balance beam supports shown in *Fig.* 12 were originally bronze sand castings that required a milling operation on the mounting surface. When these parts were changed to diecastings, all materials handling to the milling department was eliminated.

Another example of dispensing with materials handling as a result of changing to diecastings is the balance beam, *Fig.* 13. In this case, the original design was fabricated by brazing together two machined stainless steel parts.

Conclusion: It is readily apparent that the ultimate answer in improving materials handling is to try to completely eliminate the need for any handling operation, not just to improve the method for handling the material from department to department through the various manufacturing processes. Therefore, it is extremely important that all engineering sections work together to reduce materials handling throughout the plant. Only in this way can a complete materials handling program be carried out which will realize the greatest savings possible.

By this method, not only will handling operations be eliminated between production departments, but savings will also be made by eliminating parts handling by the inspection department between the various production operations. Savings can also be realized on capital expended for additional handling equipment for operations which can be completely eliminated. By going back to the basic reason for materials handling—the original design and tooling of the part—and studying the product in the light of materials handling costs, maximum savings possible can be gained.

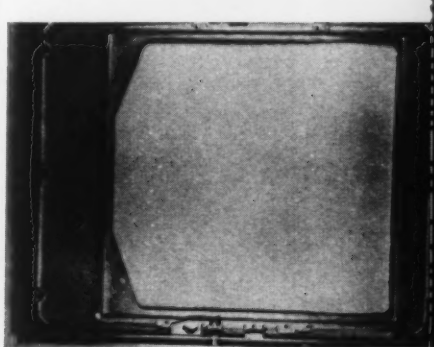


Fig. 11—Right — Die casting of small holes in this aluminum door eliminated handling parts to a second drilling operation

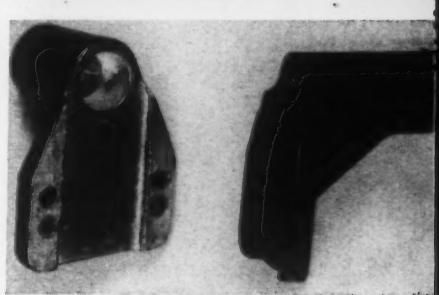


Fig. 12 — Center — Change from sand casting to die casting eliminated materials handling to milling machine for these balance beam supports

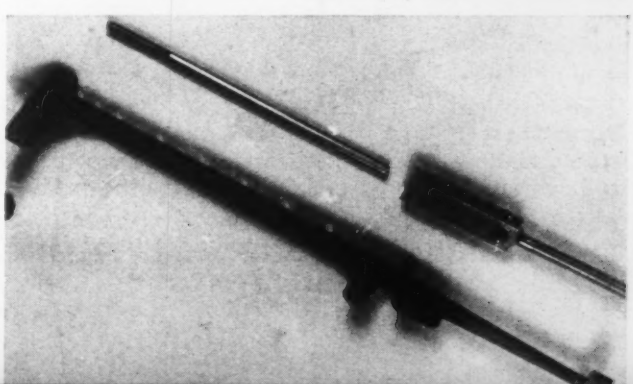


Fig. 13—Below—Die cast balance beam, replacing fabricated design, simplified handling and reduced costs

Fig. 1—X-ray gaging system

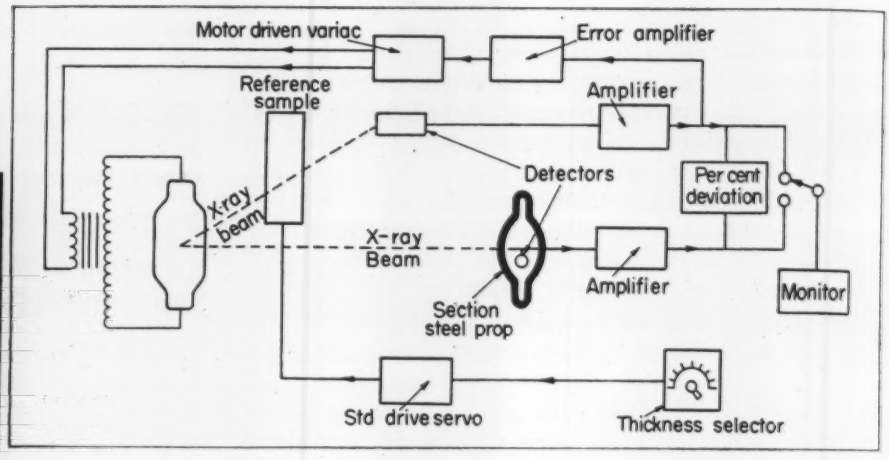
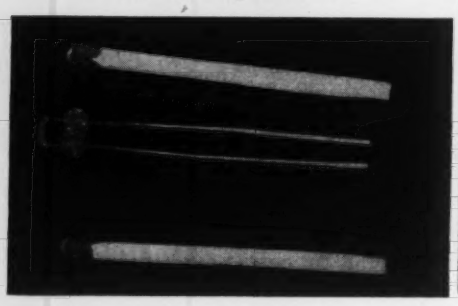


Fig. 2—Below—Small size of detector permits it to be used in confined spaces



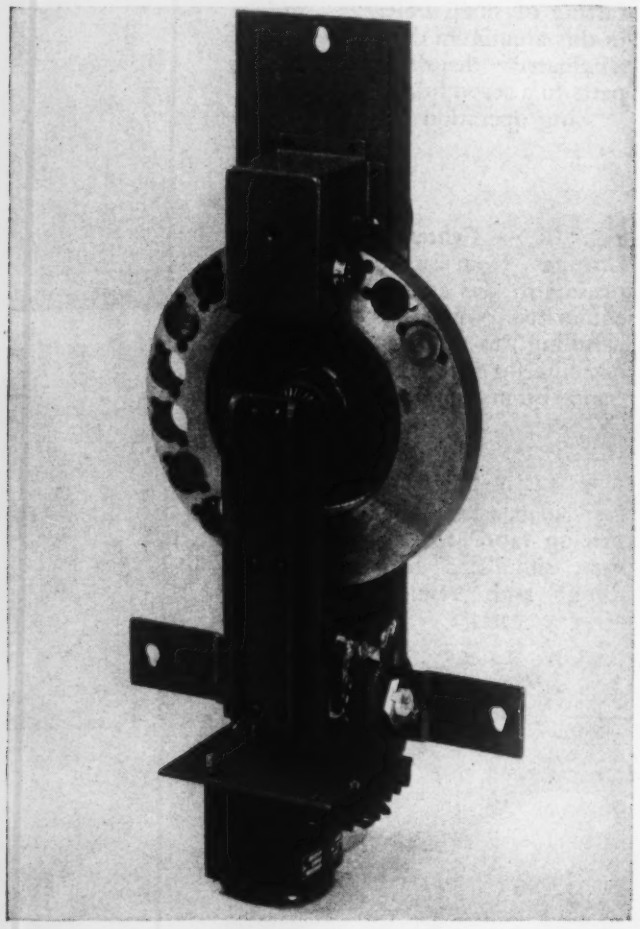
X-Ray Gaging . . . speeds prop blade production

AUTOMATIC gaging of thickness without contacting the material being measured can have many useful applications in machine control. One of the newest methods is X-ray gaging which can be used with any material which impedes the passage of X-rays, and has been successfully applied to metal gaging and rubber processing machinery.

An automatic gaging machine, for example, using X-rays has reduced the time necessary for gaging extruded propeller blades from 8 hours to less than one hour. The survey was formerly performed by hand with 18-foot-long mechanical calipers.

Essentially, the method is a comparison process in which the quantity of X-ray penetration through the blade is compared with penetration of an X-ray beam of equal strength through a metal sample of known thickness. A block diagram, *Fig.* 1, illustrates the operation of the system. Two X-ray beams approximately 1/16-inch in diameter pass through the standard sample and the propeller blade; cadmium-sulphide crystal detectors inside the propeller blade and next to the reference sample detect variation in X-ray intensity. Amplified detector output is then applied to a bridge circuit to produce a deviation reading, or may also be individually read for monitoring purposes. Output of the reference-sample channel, measured by an error amplifier which controls a motor-driven Variac to automatically adjust X-ray tube input, holds reference channel output at a fixed value.

Fig. 3—Reference samples are automatically placed in position as remote switch is operated



Propeller blades are held and manipulated by a lathe carriage. The blade detector is supported by a long, thin shaft which allows it to pass into the narrow portions of the blade. Since portions of the blade are small the detectors, *Fig.* 2, must be small. Cadmium sulphide detectors, having high sensitivity with small area, are well suited to this application.

Twelve reference samples with thicknesses varying from 0.075 to 0.500-inch are mounted in an indexing mechanism, Fig. 3, and can be automatically placed in position by setting a selector switch to the required thickness. The associated servo amplifier and control allow selection to be made swiftly and accurately from a remote position, eliminating any radiation hazard.

From a paper entitled "Automatic Metal Gaging Using X-Rays" by John F. Howell, presented at the National Electronics Conference in Chicago, September, 1952.

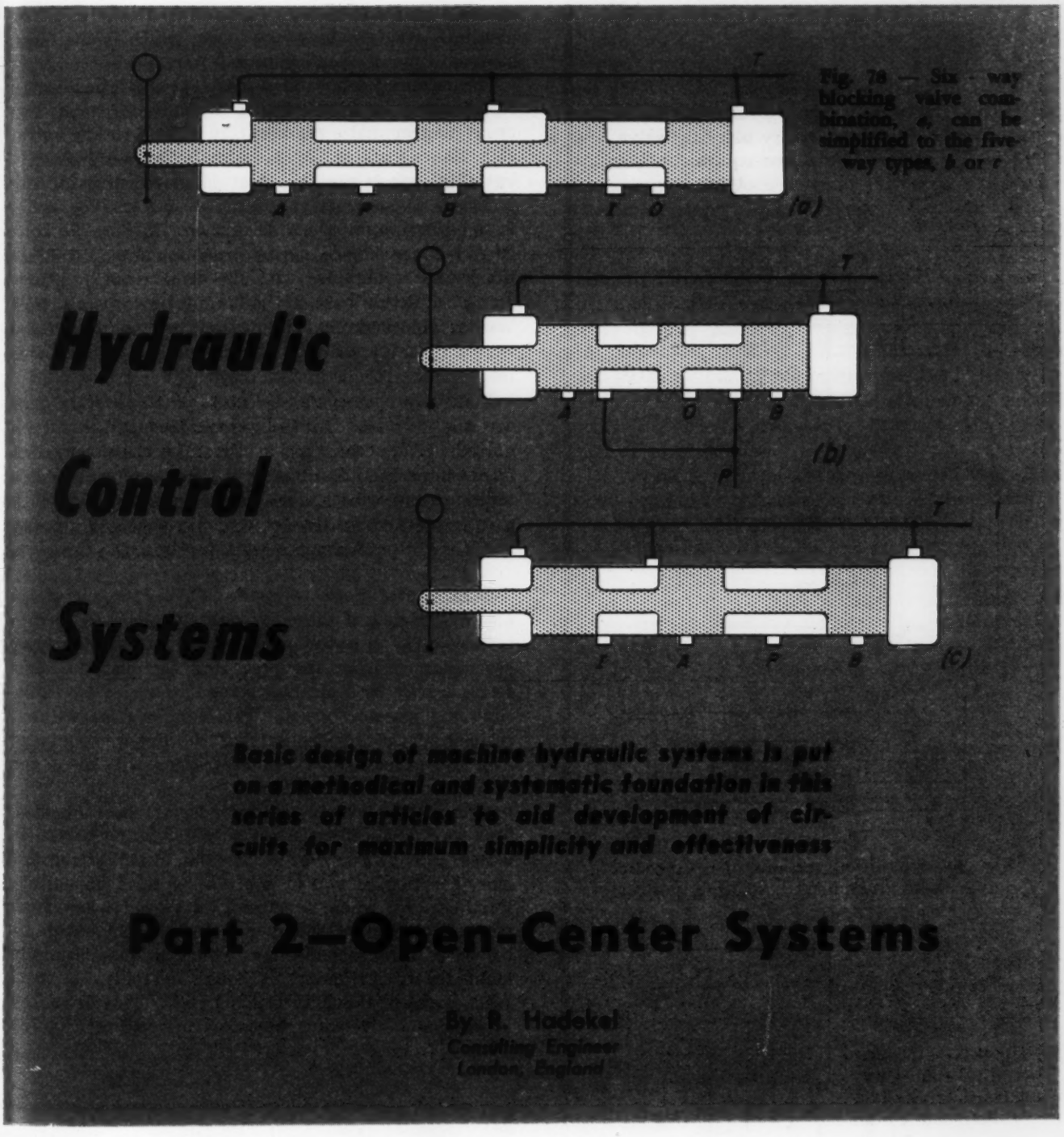


Fig. 78 — Six - way blocking valve combination, *a*, can be simplified to the five-way types, *b* or *c*

Hydraulic Control Systems

Basic design of machine hydraulic systems is put on a methodical and systematic foundation in this series of articles to aid development of circuits for maximum simplicity and effectiveness

Part 2—Open-Center Systems

By R. Hadekel
Consulting Engineer
London, England

IN THE design of hydraulic systems an important consideration is the type of basic system to use—open or closed. To indicate the main features of importance, open-center systems will be broadly discussed.

Open-Center Selectors: In systems wherein the controlled element is a double-acting cylinder, the four-way controlling selector can be made to have a central "neutral" position, and may be coupled to a blocking valve in such a way that the latter is open only in the neutral position. When the selector is returned to neutral on completion of an operation, the pump unloads through the blocking valve.

This effect may be achieved by having a three-position blocking valve, which is open in the central position only, and directly connected to a selector of the ordinary type, *Fig. 78a*. The valve shown is a six-way type, having the four normal selector connections —*P* (pressure), *T* (tank), *A* and *B* (cylinder)—plus the two blocking valve connections—*I* (in) and *O* (out). The *I* and *P* connections *may* come from the same line, in which case an external tee is unnecessary, and the valve can be simplified to the five-way type shown at *b*. Again, connections *O* and *T* may be made identical, giving the five-way type of valve

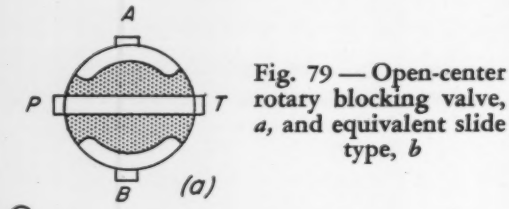
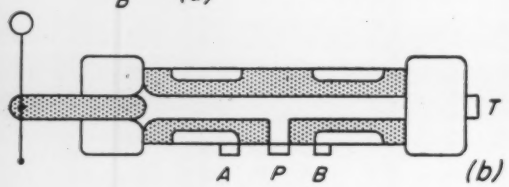


Fig. 79 — Open-center rotary blocking valve, *a*, and equivalent slide type, *b*



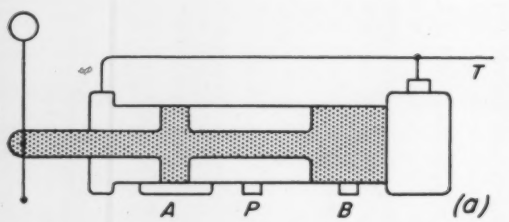
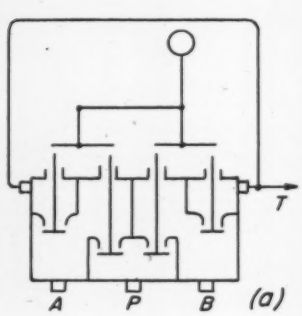
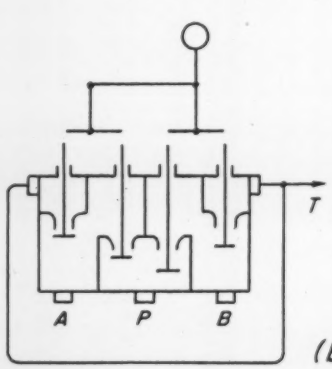


Fig. 80—Simplified versions of open-center valves with nonblocked neutral position

Fig. 81 — Seating type four-way valve, *a*, can be easily designed as an open-center style, *b*, if a fully blocked neutral is not necessary





shown at *c*. Further, both *I, P* and *O, T* may be made identical, giving a four-way valve, which is the most common type of open-center selector.

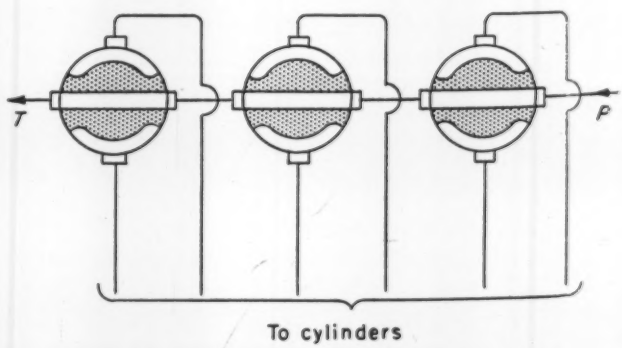
The required connections in a four-way open-center selector may be established in a number of ways. The usual diagrammatic representation for a rotary valve, *Fig. 79a*, shows the open-center action very clearly, but this type is not the most compact valve for the purpose. A shorter type is shown in *Fig. 79b*, which is the diagram for the slide version. In *Fig. 79b* both *A* and *B* are blocked in neutral, but other combinations may be obtained with the same spool by shortening the fitting part of the bore at one or both ends. With nonblocked neutral, however, it is possible to devise simpler types of valves, as shown for instance in *Fig. 80*.

Four-way open-center selectors of the seating type are easily devised if a fully blocked neutral is not required. Thus, the type of *Fig. 81a* is converted to open-center operation merely by lengthening the valve stems on one or both sides, as shown in *Fig. 81b*. With a fully blocked neutral or with five-way and six-way types, additional poppets seem inevitable.

Open-Center Series Circuits: Open-center systems are very simple if there are only cylinders to be controlled. The selector may be any of the four-way types described in the preceding section. In some cases it may be desirable to regulate speed by throttling the selector outlet. This can be done without restricting the by-pass path, if the five-way valve of *Fig. 78b* is used, since the restriction will be on the *T* and not the *O* connection.

Where there are several cylinders to be controlled, four-way open-center selectors must be connected in series, as shown in *Fig. 82*. In this circuit simultaneous operation of two or more services is impossible. Furthermore, when a selector is moved away from neutral, all the preceding selectors are in effect deprived of a tank connection, which is inadmissible in many cases, particularly (though not only) if "neutral" is not of the fully blocked type. This drawback is avoided if five-way valves of the type of *Fig. 78b*

Fig. 82—In series open-center circuit layout, necessary where more than one cylinder is to be controlled, simultaneous operation is impossible



are used in all positions except the last, where a four-way valve may still be used, as shown in *Fig.* 83. This may be described as a "semiseries" circuit, the pressure connections being in series and the tank connections in parallel.

Open-Center Systems—Series-Parallel Circuits: If no direct restriction is to be placed upon the simultaneous operation of two or more services, the full six-way type of selector shown in *Fig.* 78*a* must be used, although the first valve in the series can still be the five-way type of *Fig.* 78*b*, and the last valve can be the five-way type of *Fig.* 78*c*. The resulting circuit is shown in *Fig.* 84. The selectors proper are connected in parallel, and the blocking valves in series.

It is worth noting that certain variations are permissible in the connection combinations of series-parallel five-way and six-way valves. Thus, in the two extreme positions, the *O* connection need not be blocked and may be connected to *T*. Alternatively *I* may be connected to *P* in both extreme positions. These variations may sometimes help to shorten or simplify the selector. Note, however, that the two variations described must not be used together. In the case of selectors for single-acting cylinders, similar variations are permissible in one extreme position only—that in which the by-pass path is blocked.

Again with the more complex open-center five-way and six-way valves, and equivalent types for single-acting cylinders, various special combinations of connections are feasible in neutral besides the usual blocked, half-blocked and fully free neutral. However, the necessity for such unusual valves can be avoided by suitable circuit design and their description will be omitted.

Single-Acting Open-Center Selectors: In the case of single-acting cylinders returned by gravity, accumulator, or other external force, the pump should preferably be unloaded when the selector is in the return position as well as in the neutral position. Hence the blocking valve part of the selector must be slightly modified, if it is separate, or the whole selector design must be altered.

One possible form of the series-parallel type of selector (which in this case needs five connections) is shown in *Fig.* 85. The first and last selectors of the series circuit (corresponding to those of *Fig.* 78*b* and *c*, respectively) can be four-way valves, as shown in *Fig.* 86*a* and *b*, respectively. Corresponding to the four-way type used for double-acting cylinders is a three-way type, one form of which is shown in *Fig.* 87. For single acting cylinders, it is also possible to have

Fig. 83—Below—Semiseries open-center circuit which provides parallel tank connections but series pressure connections

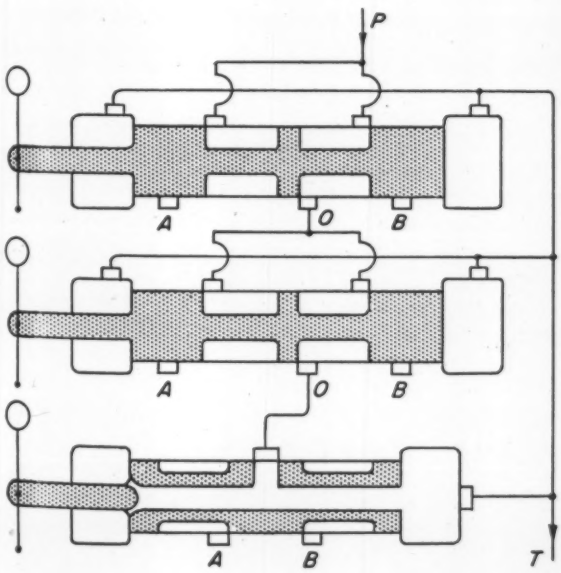
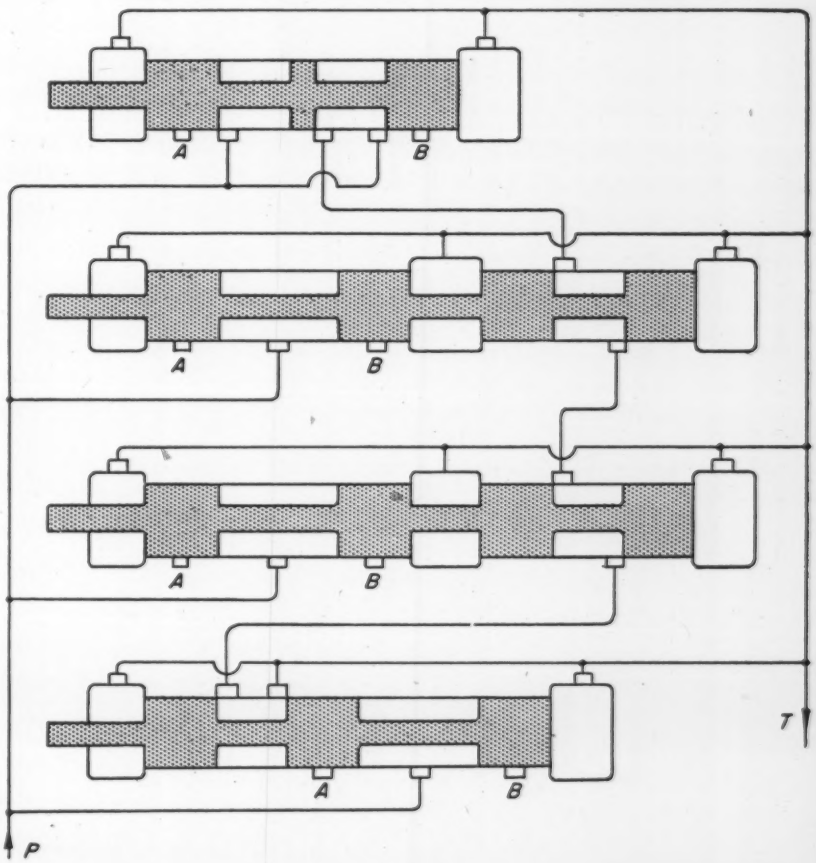


Fig. 84—Right—Series-parallel circuit without restriction on simultaneous operations



series circuits corresponding to that of *Fig.* 82, using selectors of the type of *Fig.* 87. Semiseries circuits, corresponding to that of *Fig.* 83, are possible using valves of the type of *Fig.* 86*a* with that of *Fig.* 87 in the last position.

In the case of the semiseries circuit, extension is still limited to one cylinder at a time, but return is unrestricted. There is no general restriction in using single-acting and double-acting cylinders together in the same system, provided the appropriate valves are used in each position. Note that in the case of a differential cylinder, *Fig.* 51 of Part 1, the selector must be of the type suitable for double-acting units, although one of its connections will remain unused since pressure must be available for the return stroke.

For single-acting cylinders, open-center selectors need not necessarily have a neutral position. They can, therefore, be of the two-position type, unloading being achieved in the return position only. For this purpose it is possible to devise shortened versions of the valves of *Figs.* 85 and 86. In the case of a single-acting requirement, a plain blocking valve, corresponding to the valve of *Fig.* 87 but without neutral, is all that is necessary. This is shown in *Fig.* 88.

With selectors of the type of *Figs.* 86*b*, 87 and 88, care must be taken to see that the by-pass flow does not create sufficient back pressure to prevent retraction of the cylinder.

Other Open-Center Selectors: If there are a number of services to be operated according to a predetermined cycle, and that cycle is such that one selector will always be away from neutral when any of the selectors controlling the remaining services is to be operated, a neat solution is possible by using the simplest type of open-center selector connected in *parallel* with one or more plain closed-center selectors. An example is shown in *Fig.* 89, a circuit for an injection molding machine. The cycle of operations is, (1) close dies, (2) inject, (3) retract injector, and (4) open dies. After the last operation the selector controlling die closing is brought back to neutral, and the pump is unloaded.

Combinations of open-center selectors with other unloading means often form good solutions to certain particular problems. Thus, *Fig.* 90 illustrates a circuit for a single-acting thermosetting plastic press in which pressure must be maintained for long periods. While the press is under load, the pump is unloaded by the cut-out valve, the press cylinder being of sufficient capacity to make an accumulator unnecessary. While the press is not under load, unloading takes place through the open-center selector.

Automatic Open-Center Selectors: Ordinary open-center selectors must be either deliberately returned to neutral when an operation is completed or, if spring-centered, held away from neutral for the duration of the operation. Where neither of these methods is acceptable, use is sometimes made of selectors which return to neutral automatically under specified conditions.

Usually return is controlled by pressure, or possibly flow, at the pressure inlet connection *P*. One solution is to have a lever which is spring-centered, but held by catches in the end positions, the catches being released by the automatic control mechanism. If the latter responds directly to pressure at the inlet connection, the use of a relief valve in the circuit is not absolutely essential.

This type of action is obviously unsuitable in cases where the machine must remain at standstill under load for definite periods as in a plastic press.

Neutralizing may also be made to depend on pressure or flow in one of the lines to the cylinder or in any other part of the circuit, or again on the position of the actuated mechanism through a pilot valve, for instance. Circuits of this type come under the category of automatic sequence systems, and will be dealt with in a later part of this series.

Limitations of Open-Center Systems: Apart from the automatic version just described, open-center selectors are characterized by the fact that, in general, the lever must be deliberately returned to neutral to obtain unloading, or, if the lever is spring-centered, it must be held in the extreme position for the duration of the operation.

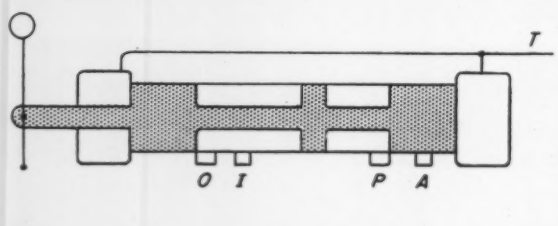
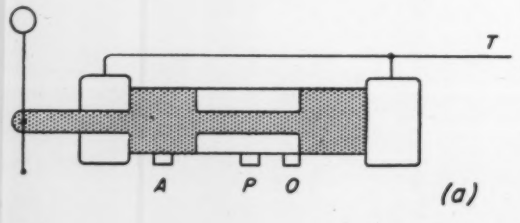


Fig. 85 — Left — Series-parallel selector valve for single-acting cylinders



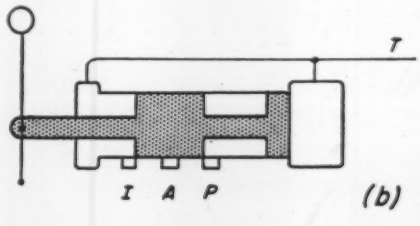


Fig. 86—Below—Series-parallel valves for first, *a*, and last, *b*, positions in circuit

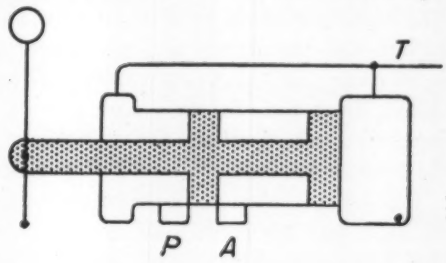


Fig. 87—One form of three-way selector for single-acting cylinders corresponding to the typical four-way valve for double-acting types

The use of a valve with "stay put" action implies the danger that the centralizing operation may be forgotten, and hence open-center selectors should preferably be of the spring-centered type. If the machine has a cycle of operations such that there is no likelihood of the lever being left in *one* of the extreme positions, it may be arranged if desired to stay put at that position, but should still be spring-returned to center from the opposite position. In the case of single-acting cylinders, the selector may be either spring-centered to neutral or spring biased to return. If the machine has an operating cycle such that there is no likelihood of the selector being left in the forward position, a stay-put type of lever action should be quite satisfactory.

In the general case, open-center systems are a good solution where it is not an inconvenience to hold the selector lever for the duration of the operation. In many applications the lever would be held for the duration of the operation in any event, examples being joggling presses, lifting trucks, and most machines in which the cylinder does not usually travel to its full extent.

Open-center systems do not lend themselves very well to automatic machine applications, nor to pilot control. Where there are a number of independent services worked by one pump, and no direct restriction is to be put on simultaneous operation of two or more units, the series-parallel system must be used. This involves the rather complicated and cumbersome six-way type of selector, in the most general case, and such systems are usually confined to cranes, vehicles, and other mobile applications.

Pilot Valve Coupled Systems: The series-parallel system of *Fig.* 40 of Part 1 involves in effect a full size unloading valve on each selector, and full flow passages between the unloading valves. These can be avoided by vesting the unloading function in a single separate valve, with suitable pilot control elements on each selector.

If the selectors are located close together, it is also possible to devise a system with a direct-operated

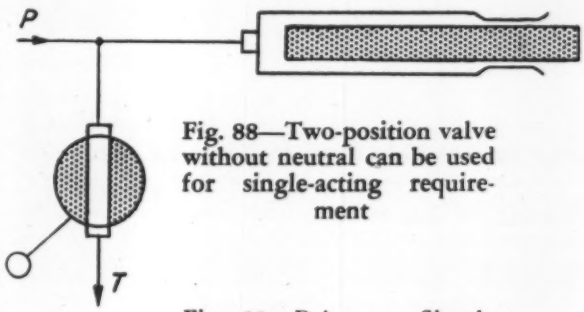
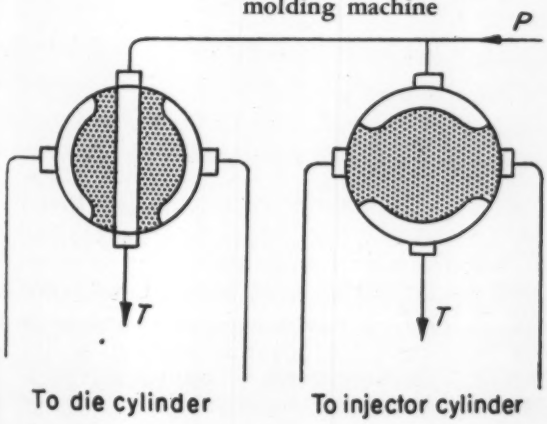


Fig. 88—Two-position valve without neutral can be used for single-acting requirement

Fig. 89—Below — Simple circuit for an injection-molding machine



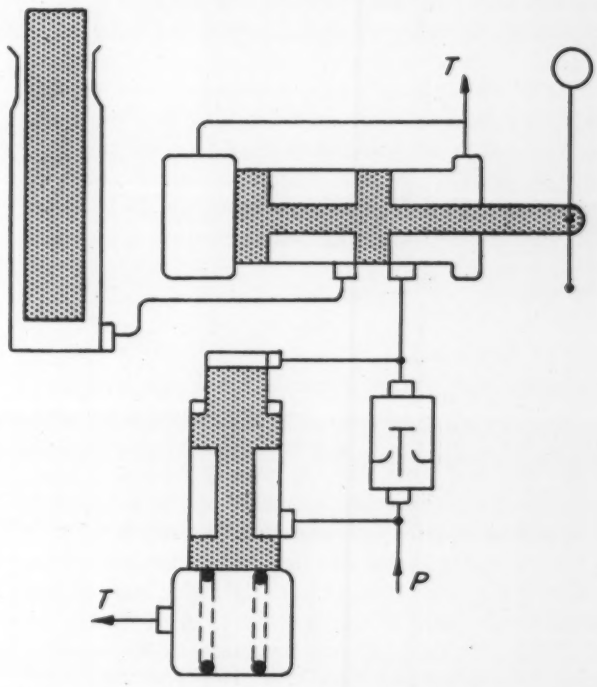


Fig. 90—Open-center system with unloader for single-acting thermosetting plastic molding press

blocking valve, *mechanically* coupled to the selector levers in such a manner as to be closed when *any one* of these levers is moved away from neutral.

Systems of the pilot type can be devised which are equivalent to ordinary open-center circuits, and depend on return of levers to neutral. In similar systems the selectors themselves are pilot-operated. At this point only circuits which have the characteristic of not being dependent on centralizing selector levers will be considered. Systems of this type can be obtained by fitting a spring-returned pilot element to each selector, which is operated by a cam lever in such a manner that the pilot valve is operated when the lever crosses from one extreme position to the other. If neutral is required, operation is from neutral to either extreme position but, in any event, is released again as the lever reaches the extreme and, where applicable, also the neutral position.

Several circuits can be devised on this basis, and one by way of example is shown in *Fig.* 28 of Part 1 of this series. The pilot valves V_1 on the selectors are depressed during the course of the lever travel and released again as already described, but are prevented from returning rapidly by some form of dashpot action (not shown). When any of the selectors is operated, pressure is admitted through connection A on V_1 to connection C on the unloading valve, closing the latter. At this time connection B on pilot valve V_2 is to tank, but the resistance R_1, maintains sufficient pressure to close the unloading valve. When the latter is closed, fluid from the left-hand side of valve V_2 leaks back to tank through the resistance R_2, and valve V_2 returns to the left under the action of the spring. Port B on valve V_2 is thus connected to the pressure main, and pressure is maintained on connection C of the unloading valve, keeping the latter closed even though valve V_1 resets.

When the operation is completed, fluid blows off through the relief valve and, due to resistance R_2, sufficient pressure is generated to move valve V_2 to the right, allowing fluid from connection C on the unloading valve to return to tank through the resistance R_1 and causing the unloading valve to open. When this happens the relief valve of course closes, but valve V_2 is still kept operated by the outlet flow from the unloading valve, the resistance R_2 being sufficiently low to prevent undue restriction of the by-pass path. Delay in the resetting of valve V_1 will delay opening of the unloading valve, which is not harmful.

The third part in this series, which will appear in the succeeding issue, will cover the area of pilot and electrical control of hydraulic systems.

Airframe Control Bearing Selection

FOR selection of airframe control bearings new criteria which more closely simulate flight conditions have been developed by the Bureau of Aeronautics, the U. S. Air Force, the National Standards Committee and the Anti-Friction Bearing Manufacturers Association. Heretofore, control bearings have been rated and selected solely on the basis of a static "nonbrinell" value which was required to exceed the critical limit load on the control positions. The nonbrinell value was determined from KNd^2 where N = number of balls; d = ball diameter, inches; and K = a constant. For deep groove bearings, K = 5000 to 5500, and for self-aligning bearing types, K = 2400 to 2800.

Such factors as normal or combined loads, differences in applications and cycles are obviously ignored in this method. Consequently, added weight and expense were often incurred since the available capacity, or life, of a bearing was seldom fully utilized.

During development of the new method of selecting bearings for airframe use, it was determined that static loading, considerably in excess of the nonbrinell loads, could be applied without affecting smooth operation or life under loads and oscillatory motion. This allowable static load which is nearly twice that of the old nonbrinell loads is equivalent to a K factor of about 10,000 for deep groove bearings, 3800 for self-aligning bearings, and 3200 for rod end bearings. Designated as "Limit Load Rating" it never exceeds two-thirds of the bearings' minimum static fracture strength.

By means of load-life data the new system permits the selection of the smallest bearing which will operate satisfactorily for the desired life. The data were obtained in tests conducted by the Fafnir Bearing Co. and are based upon 90-degree oscillatory cycles. From the data, formulas for rating and life factors were developed and convenient tables and graphs of factors have been built.

In the selection of a bearing by the new rating method, there are two basic steps: (1) Selecting a bearing which has a radial limit load rating equal to or in excess of the limit load encountered on the application; (2), checking the oscillatory rating of the bearing to insure that the desired average life will be obtained under the loading expected in the normal service life of the aircraft.

In service, the load on a control position normally varies in magnitude and frequency. When the different loads and their frequency are known, the equivalent load is calculated from

$$P = \sum \frac{K_i P_i^{3.6}}{3.6}$$

where P = equivalent load, lb; P_i = actual applied load, lb; and k_i = proportion of service time that P_i is applied.

As an example, a particular application carries a load of 500 lb for 15 per cent of the total service time, 1000 lb for 75 per cent and 200 lb for 10 per cent. The equivalent load on this bearing is $P = [0.15(500)^{3.6} + 0.75(1000)^{3.6} + 0.10(2000)^{3.6}]/3.6 = 1208$ lb.

As more information is accumulated, the effects of other factors will be incorporated in the new system.

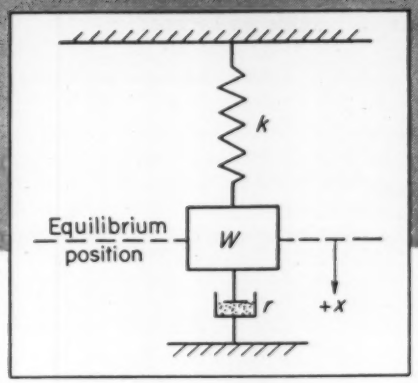
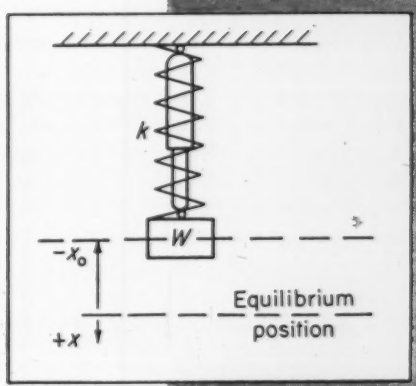


Fig. 1—Representation of a viscous-damped spring - mass system having one degree of freedom

Fig. 2—Diagram for damped free vibration



Numerical Analysis of Damped Vibrating Systems

By E. Stanley Ault and William J. Graff Jr.

Professor of Machine Design
Purdue University
Lafayette, Ind.

Senior Propulsion Engineer
Consolidated-Vultee Aircraft Corp.
Fort Worth, Tex.

A RECENT study of automobile hydraulic shock absorbers has indicated need for a method of analysis useful in the prediction of the damping effect of such an absorber on a vibrating system. This article presents a numerical procedure based on the damping force characteristics of the absorber. By this procedure the damped vibration differential equation may be solved and the resulting decay wave plotted.

For simplicity damped free vibration with one degree of freedom will be assumed in the discussion of the numerical procedure. The method of obtaining the absorber damping force characteristic curves will be outlined and the results shown for one such determination. An example problem will illustrate the numerical solution and the use of the experimental resisting force curves.

Numerical Procedure: Viscous damping is the simplest type of damping to consider in vibration problems. With viscous damping the resisting force developed within the absorber is proportional to the first power of the velocity of the vibrating mass.

Let the sketch in *Fig.* 1 represent a spring-mass system with viscous damping having only one degree of freedom. The differential equation for this system may be written:

$$\frac{W}{g}\frac{d^2x}{dt^2} + r\frac{dx}{dt} + kx = 0$$

where r is the proportionality constant in pounds per unit velocity between the velocity and the resisting force of the absorber, and k is the proportionality constant in pounds per inch of deflection to displacement. From this second-order linear differential equation the solution to the case of oscillatory motion is

$$x = e^{-rgt/2W}\left[At\cos\sqrt{\frac{kg}{W} - \left(\frac{rg}{2W}\right)^2} + Bt\sin\sqrt{\frac{kg}{W} - \left(\frac{rg}{2W}\right)^2}\right]$$

The exponential in this general solution decreases with time—a result that one might expect from looking at the physical nature of the problem. The original or initial amplitude of vibration gradually diminishes with time, the rate of decay being dependent upon the factor $rg/2W$, or more specifically,

on the damping constant r. The two exponentials,

$$x = \pm x_0 \, e^{-rgt/2W}$$

where x_0 is the initial displacement, form envelopes between which the oscillatory motion occurs.

In many practical problems the damper contributes to the system a resisting force which in general does not vary as the first power of the velocity. When the damping becomes proportional to some higher power of the velocity, there is no simple straightforward mathematical solution and other methods are needed. The numerical analysis presented here constitutes one method of solution for such problems, and is discussed for an automobile hydraulic shock absorber of the direct-acting type.

In *Fig.* 2 the arrangement shown denotes a spring mass system, similar to that of *Fig.* 1, with the substitution of a commercial automobile hydraulic shock absorber for the viscous damper. The automobile shock absorber in general does not offer viscous damping to the vibrating system. That is, the damping force no longer builds up as a constant times the velocity.

If the damping force is expressed simply as some function of the velocity, the following differential equation results:

$$\frac{W}{g}\frac{d^2x}{dt^2} + f\left(\frac{dx}{dt}\right) + kx = 0$$

The $f(dx/dt)$ term in this equation may be determined experimentally in the form of a curve. The shock absorber is driven through a known cycle of motion and the force-velocity relationship for each stroke is plotted.

The numerical method of solution hinges basically on the fact that in the integration process the ordinate of the integral curve represents the accumulated area under the original curve up to that point. Take the curve shown in *Fig.* 3*a* as an illustration. The area under the curve corresponding to the first small time interval is equal to the average ordinate multiplied by Δt. When this factor is added to the initial value of the integral curve, the resulting quantity in turn represents the ordinate of the velocity curve at the end of the first increment of time, *Fig.* 3*b*. That is,

$$\left(\frac{dx}{dt}\right)_1 = \left(\frac{dx}{dt}\right)_0 + (\Delta t)\left(\frac{d^2x}{dt^2}\right)_{01\text{-}av}$$

$$\left(\frac{dx}{dt}\right)_2 = \left(\frac{dx}{dt}\right)_1 + (\Delta t)\left(\frac{d^2x}{dt^2}\right)_{12\text{-}av}$$

$$\left(\frac{dx}{dt}\right)_3 = \left(\frac{dx}{dt}\right)_2 + (\Delta t)\left(\frac{d^2x}{dt^2}\right)_{23\text{-}av}$$

The time intervals Δt do not have to be equal in this method. However, it is convenient to make them so.

Having obtained the velocity curve by drawing a smooth line through the derived points, one is now ready to integrate the velocity curve to obtain the displacement curve, *Fig.* 3*c*. The procedure is the same as before:

$$x_1 = x_0 + (\Delta t)\left(\frac{dx}{dt}\right)_{01\text{-}av}$$

$$x_2 = x_1 + (\Delta t)\left(\frac{dx}{dt}\right)_{12\text{-}av}$$

$$x_3 = x_2 + (\Delta t)\left(\frac{dx}{dt}\right)_{23\text{-}av}$$

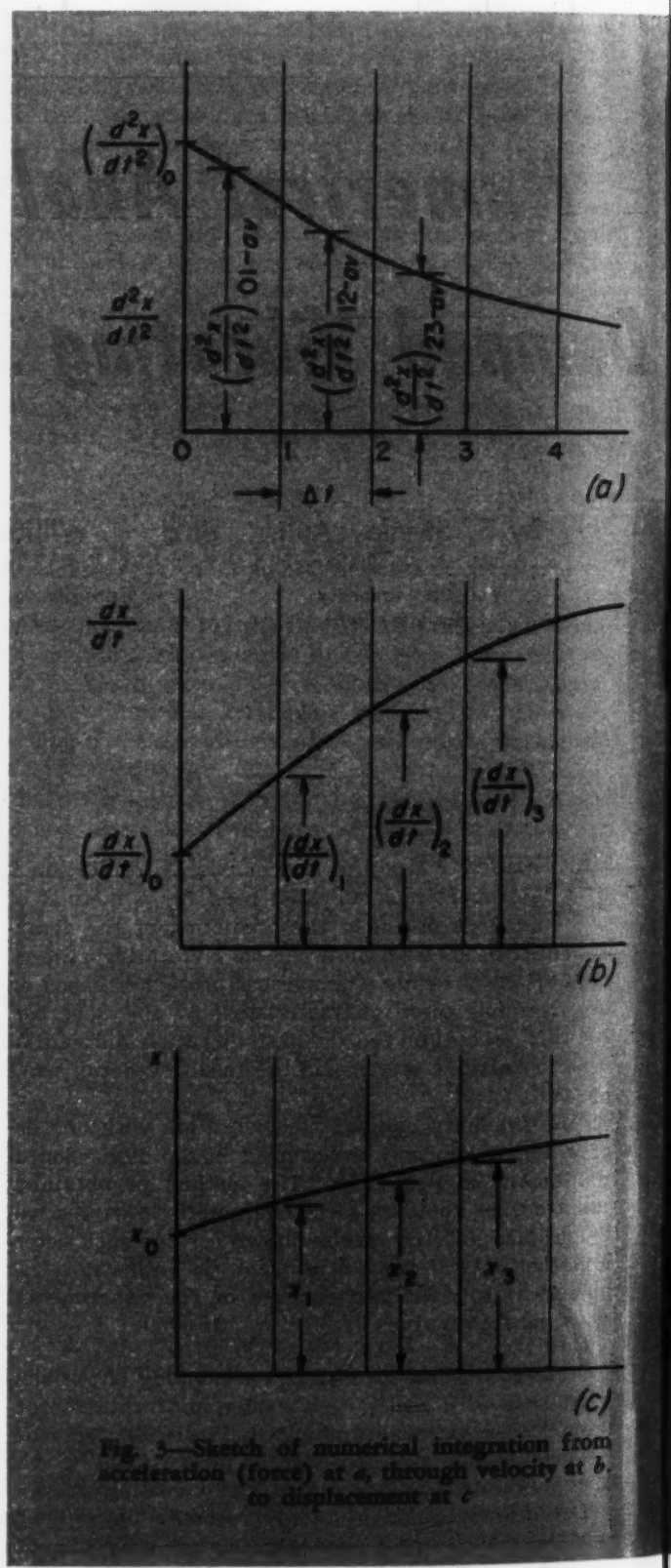


Fig. 3—Sketch of numerical integration from acceleration (force) at *a*, through velocity at *b*, to displacement at *c*

The accuracy of the method, of course, depends on the magnitude of the time intervals Δt. As their size is reduced, the accuracy of the solution increases.

The computation of these increment areas with a calculating machine may be facilitated by the following approximations:

$$(\Delta t)\left(\frac{d^2x}{dt^2}\right)_{01\text{-}av} \approx (\Delta t)\frac{\left(\frac{d^2x}{dt^2}\right)_0 + \left(\frac{d^2x}{dt^2}\right)_1}{2}$$

$$\approx \frac{(\Delta t)}{2}\left(\frac{d^2x}{dt^2}\right)_0 + \frac{(\Delta t)}{2}\left(\frac{d^2x}{dt^2}\right)_1$$

In order to begin the numerical solution initially, one must compute the value of $(d^2x/dt^2)_0$. From knowledge of the initial displacement and the initial value from the force-velocity curve, the initial acceleration may be computed from

$$\left(\frac{d^2x}{dt^2}\right)_0 = \frac{-f\left(\frac{dx}{dt}\right)_0 - kx_0}{\frac{W}{g}}$$

Curves of acceleration and velocity may be constructed as the solution progresses and by extrapolation, one may estimate each new value of acceleration to use. However, this procedure is not absolutely necessary. At the beginning, one may assume that the acceleration does not change over the first time interval and on this basis compute the value of x_1. With this value of x_1, the following equation may be solved:

$$\left(\frac{d^2x}{dt^2}\right)_1 = \frac{-f\left(\frac{dx}{dt}\right)_1 - kx_1}{\frac{W}{g}}$$

Thereby a more correct value for the acceleration can be obtained. With this new acceleration value, the numerical processes are repeated and a second x_1 determined. This succession is repeated until the proper value $(d^2x/dt^2)_1$ is established corresponding to correct x_1. For succeeding computations, the operator may simply choose a value of the next acceleration and by repeated refinenment establish and check

Fig. 4 — Force - velocity curves for extension stroke

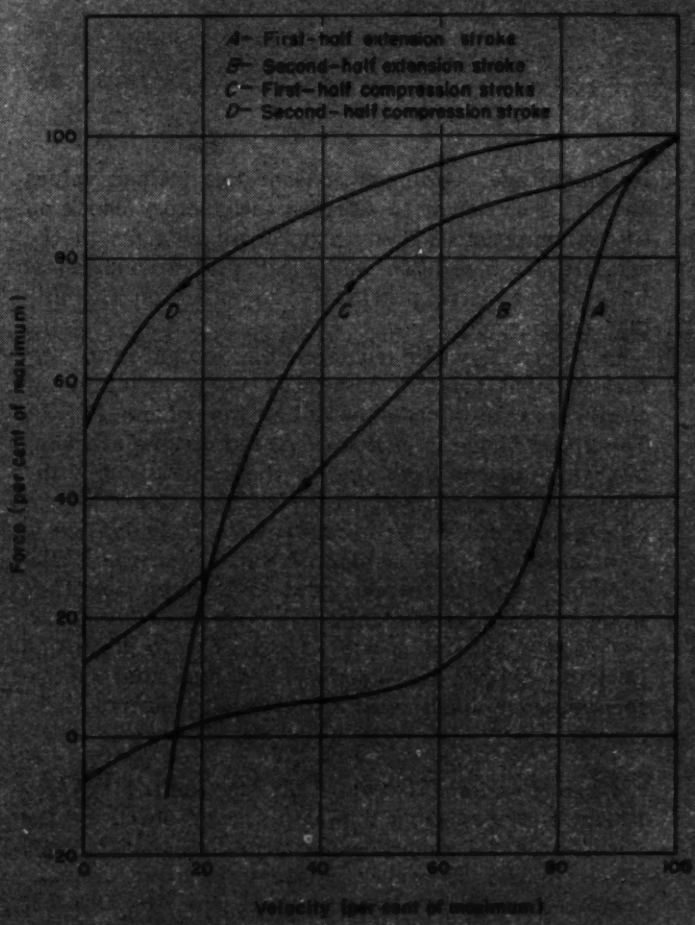


Fig. 5—Characteristic force - velocity curves

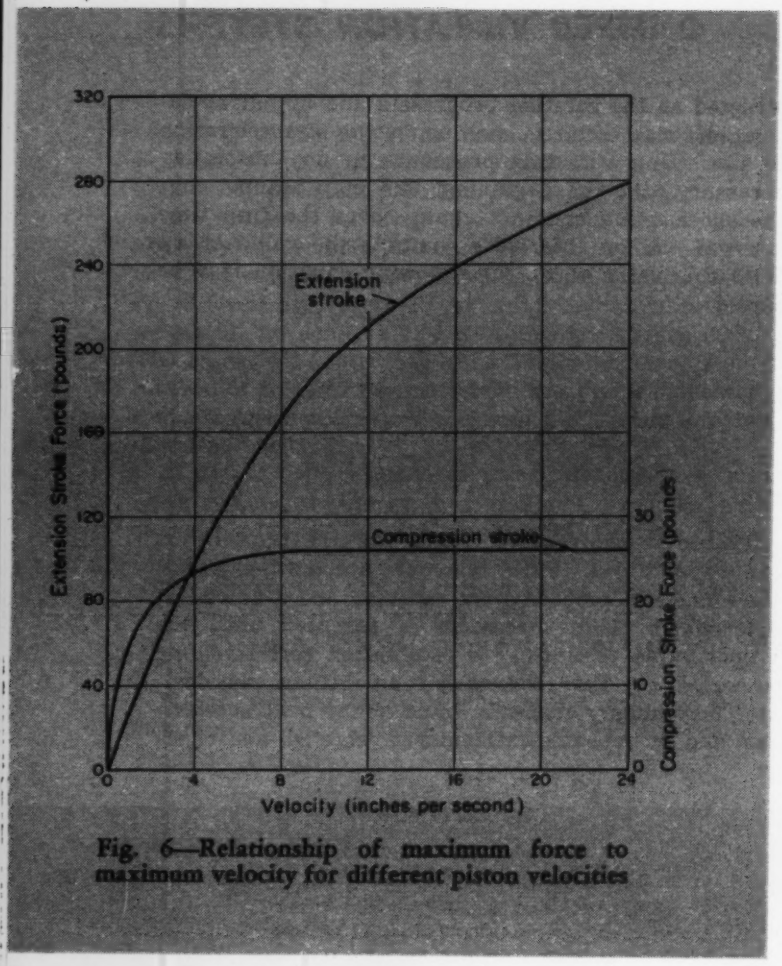


Fig. 6—Relationship of maximum force to maximum velocity for different piston velocities

its magnitude. Ordinarily one or two refined values should be sufficient to afford a satisfactory check on the computations. Frequently, small changes in the acceleration quantities will, after the two numerical integrations, have practically no effect on the displacement wave.

In TABLE 1, which contains the computations for the example solution presented later, one note of clarity may be in order regarding the column d^2x/dt^2. The upper figure in each row represents the acceleration value at the beginning of the interval, while the lower one represents the estimated value at the end of the time interval. As the row of calculations is completed and this estimated value confirmed, the checking value is then entered as the upper number in the next row of the table.

The two columns x and $t = \Sigma(\Delta t)$ are plotted to give the desired solution to the spring-mass system for whatever starting or initial conditions have been chosen.

Characteristic Curves: The function of velocity which describes the damping force produced by the absorber is determined experimentally. For the particular absorber whose characteristic or average force-velocity curves are presented here, the absorber was mounted in a simple harmonic motion testing machine and driven through different strokes at various speeds.

The absorber force was obtained from a calibration curve of the strain readings for a strain member utilizing SR-4 gages which recorded directly on an oscillograph. The strain member was comprised of a thin steel tube positioned between two end pieces and placed initially in compression by tightening of the central bolt which held the assembly together. The resistance developed by the shock absorber when driven in the testing machine was measured by the change in strain in the steel tube. That is, readings denoted either the addition or release of compression within the tube.

The test results were drawn as curves showing the resisting force plotted against velocity of the absorber piston. These curves were reduced to a more convenient form by expression of both the force and the velocity in percentages of their respective maximum values. The midstroke velocity was, of course, the maximum because the tests were performed with harmonic motion. In some instances the maximum force occurred slightly after midstroke, although this occurrence was not marked enough to materially affect the use of the midstroke as the maximum in this work.

In *Fig.* 4 the force-velocity curves are shown for the extension stroke of one absorber. Reduced and expressed as just described, these ten curves were combined to produce one synthesized curve, called the characteristic extension-stroke force-velocity curve. In a similar manner, the ten individual compression-stroke force-velocity curves were reduced to percentages of maximum values and averaged to produce one curve. *Fig.* 5 shows the characteristic force-velocity curves for both strokes of this same absorber.

Because the characteristic force-velocity curves are given as fractions of the maximum values, plotted curves are required for relating the maximum force to the maximum velocity for different piston velocities. *Fig.* 6 gives this relation, again for the same absorber.

Example: As an illustration of the application of the described numerical method, let the absorber whose force-velocity relationships are shown in *Fig.* 5 be incorporated in a spring-mass system. Referring to *Fig.* 2, assume the weight W to be 750 pounds, the spring constant k to be 300 pounds per inch, and the initial displacement x_0 as -2.05 inches.

The numerical solution to the differential equation was obtained from several of the force-velocity curves which nearest fitted the problem in order that the correct decay wave might be established as nearly as possible. The curve of this solution is represented by the solid line in *Fig.* 7.

The purpose of this example is to show the use of the characteristic force-velocity curves in the numerical solution and the comparison of the decay wave so obtained with that established as the approximately correct decay wave.

Because the system was displaced from equilibrium initially by compression of the absorber, the extension-stroke characteristic force-velocity curve was used first in the numerical procedure. From the velocity equation for simple harmonic motion, the maximum

Table 1—Example Problem Solution from Characteristic Curves

$t = \Sigma\Delta t$	$\frac{d^2x}{dt^2}$	$\frac{dx}{dt}$	x (inches)	% Max. Vel.	% Max. Force	$-f\left(\frac{dx}{dt}\right)$	$-kx$	$-f\left(\frac{dx}{dt}\right)-kx$
First Extension Half Cycle: max. vel.=25.4 in./sec; max. force=287 lb								
0	328/308	0	−2.050	0	−7.5	22.0	615	637
0.025	308/273	7.95	−1.951	31.3	4.7	−14.0	585	599
0.050	273/120	15.21	−1.666	60.0	11.2	−32.0	498	530
0.075	124/−2	20.12	−1.220	79.0	43.5	−125.0	366	241
0.100	−3/−95	21.64	−0.700	85.2	75.5	−217.0	210	−7
0.125	−95/−149	20.41	−0.174	80.0	83.0	−238.0	52	−186
0.150	−151/−187	17.36	0.298	68.3	72.0	−206.0	−89	−295
0.175	−188/−200	13.14	0.679	51.7	56.3	−162.0	−204	−366
0.200	−202/−200	8.29	0.947	32.6	38.3	−109.0	−284	−393
0.225	−200/−178	3.26	1.091	12.8	22.0	−63.0	−327	−390
First Compression Half Cycle: max. vel.=13.0 in./sec; max. force=25.5 lb								
0.250	−175/−148	−1.46	1.113	−11.2	23.0	−6.0	−334	−340
0.275	−149/−120	−5.50	1.026	−42.3	−72.5	18.0	−308	−290
0.300	−119/−78	−8.86	0.846	−68.2	−89.0	23.0	−254	−231
0.325	−79/−33	−11.32	0.594	−87.0	−94.0	24.0	−178	−154
0.350	−32/17	−12.72	0.294	−97.8	−98.6	25.0	−88	−63
0.375	17/65	−12.90	−0.026	−99.2	−99.6	25.4	8	33
0.400	65/106	−11.88	−0.336	−91.4	−100.0	25.5	101	126
0.425	106/137	−9.74	−0.606	−75.0	−99.0	25.2	182	207
0.450	137/154	−6.70	−0.811	−51.5	−93.0	24.0	243	267
0.475	154/150	−3.06	−0.933	−23.5	−80.0	20.0	280	300
Second Extension Half Cycle: max. vel.=10 in./sec; max. force=192 lb								
0.500	151/150	0.74	−0.962	7.4	−3.0	6.0	286	294
0.525	133/94	4.31	−0.899	43.1	6.6	−12.5	270	257
0.550	94/12	7.15	−0.756	71.5	23.6	−45.0	227	182
0.575	13/−30	8.48	−0.560	84.8	74.0	−142.0	168	26
0.600	−30/−51	8.27	−0.350	82.7	85.4	−164.0	105	−59
0.625	−51/−65	7.26	−0.156	72.6	76.4	−147.0	47	−100
0.650	−63/−66	5.81	0.008	58.1	62.0	−119.0	−3	−122
0.675	−66/−66	4.19	0.133	41.9	46.0	−88.0	−40	−128
0.700	−65/−60	2.54	0.217	25.4	32.4	−61.0	−65	−126
0.725	−59/−45	0.98	0.261	9.8	19.5	−37.0	−78	−115
Second Compression Half Cycle: max. vel.=3.2 in./sec; max. force=22 lb								
0.750	−45/−30	−0.32	0.269	−10.0	29.5	−6.5	−81	−87
0.775	−30/−23	−1.26	0.249	−39.5	−69.5	15.3	−75	−60
0.800	−23/−14	−1.92	0.209	−60.0	−86.0	18.9	−63	−44
0.825	−14/−4	−2.38	0.155	−74.4	−90.4	19.9	−46	−27
0.850	−4/6	−2.60	0.093	−81.2	−92.2	20.2	−28	−8
0.875	7/16	−2.58	0.028	−80.7	−99.7	21.9	−8	13
0.900	16/25	−2.29	−0.033	−71.6	−98.5	21.7	10	32
0.925	24/28	−1.78	−0.084	−55.7	−94.5	20.8	25	46
0.950	28/30	−1.13	−0.120	−35.3	−86.5	19.0	36	55
0.975	30/30	−0.40	−0.139	−12.3	−72.4	15.9	42	58
1.000		0.35	−0.140					

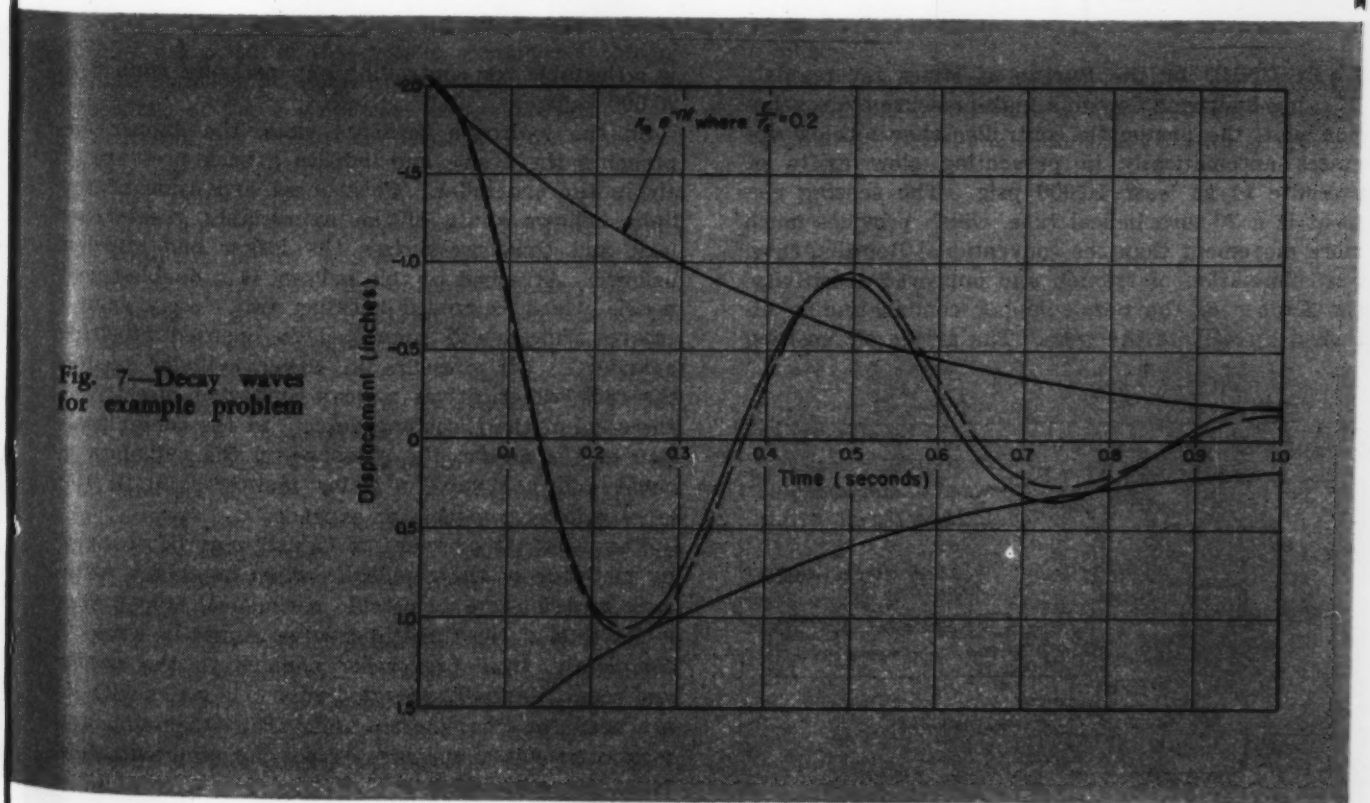


Fig. 7—Decay waves for example problem

velocity was used to estimate the maximum force to be expected on this stroke. The estimate was 287 pounds, as read from the extension-stroke curve in *Fig.* 6. Thus the numerical solution, TABLE 1, was set up with the percentage columns based on these figures.

The period of damped vibration was not expected to differ greatly from the period of free vibration which was 0.507-second. Therefore, in the numerical solution the time interval Δt was chosen as 0.025-second—or approximately twenty points per cycle.

At the start of the first compression half cycle, evaluation of the abscissa and ordinate of the characteristic force-velocity curve was again necessary, this time from the compression-stroke curve. The amplitude of 1.091 inches corresponded to a maximum velocity of 13.5 inches per second. For convenience, the maximum velocity was chosen as 13.0 inches per second. From the compression-stroke curve of *Fig.* 6, the 25.5 pound maximum force was determined.

At the beginning of the second extension half cycle, the highest possible velocity was found to be 11.5 inches per second. Influenced by that part of the solution already completed, the maximum velocity was set at 10 inches per second. As in the first extension half cycle, a peak force of 190 pounds was established.

The maximum velocity of 3.2 inches per second chosen for the second compression half cycle was only slightly under the highest possible value commensurate with the amplitude. The maximum force was determined as in the first compression half cycle.

As *Fig.* 7 shows, the two solutions are almost identical. The marked agreement between the two decay waves would seem to validate the use of the characteristic force-velocity curves in this type of problem. In the numerical solution, the convenience of referring to only two curves instead of a whole family of curves, as was done in establishing the solid curve shown in *Fig.* 7, would further justify their use.

The logarithmic decrement for these damped free vibration curves was computed to establish an approximately equivalent coefficient of viscous damping. It was found that a ratio of r/r_c equal to 0.2, where r_c is the critical damping coefficient given by $\sqrt{4kW/g}$, most nearly approximated the envelopes of the damped curve. There was no discernible difference between the period found by numerical integration and that of free vibration, although the damped vibration period should have been slightly greater.

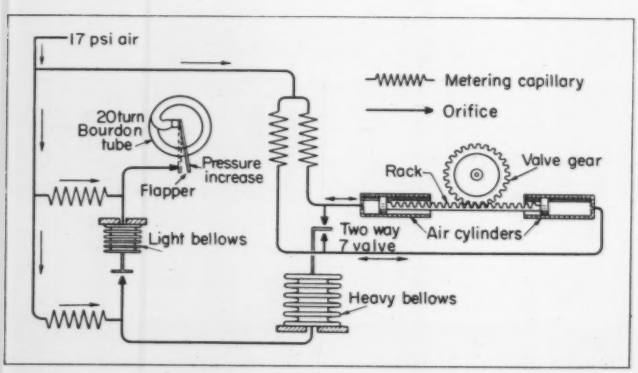
The effect of the vastly unequal build-up of resistance on the two strokes of the absorber is clearly evidenced by the second half cycle which is not damped sufficiently to remain within the approximate envelope.

The equivalent coefficient of viscous damping of 0.2 determined in this example applies only to the particular initial amplitude chosen at the start of the problem. Absorbers with characteristics other than viscous display different degrees of damping under varied conditions of frequency and amplitude*. For instance, if the initial amplitude in this example had been about 0.5 inch, the equivalent viscous damping coefficient would have been about 0.45.

*B. E. O'Connor—"Damping in Suspensions," *SAE Journal*, Vol. 54, No. 8, Aug. 1946, Pages 389-393, 411.

High-Pressure Pneumatic Controller

DESIGNED by the Bureau of Mines for regulating hydrogen flow to a high-pressure hydrogenation unit, the pneumatic controller shown below operates automatically in preventing slow drifts of pressure to at least 10,000 psig. The sensing element is a 20-turn helical tube, which provides much more movement than the conventional Bourdon tube. For elimination of friction and improved sensitivity, the flapper of the nozzle-flapper combination is attached directly to the tube. The air nozzle position is adjustable for controlling any pressure from 0 to 20,000 psig.



As the hydrogen pressure rises, the flapper approaches the nozzle and induces a back pressure of air in the controller. Consequent expansion of the light bellows shuts off an appreciably greater air leak and thus pressurizes the larger and sturdier bellows. Attached to this bellows is a double-coned needle which is moved between two closely spaced escape orifices and connected to opposed air-drive cylinders. Air pressure in either cylinder pushes the rack which drives a gear connected directly to the stem of the throttling valve. At the center position of the needle, the pressure on the cylinders is equal and the valve remains motionless until the large bellows contracts or expands.

The usual air pressure of 17 psig may be changed by metering of the capillaries when necessary. The rack contains two adjustable mechanical stops. One is set so that the throttling valve cannot be shut off completely, thus preventing damage to the needle and seat. Manually operated valves, in series with it, are used for complete shut-off. The other stop, for maximum valve opening, is set for approximately twice the necessary flow.

MECHANICAL LINEARIZER

. . . a design for transforming a function with a "calibration" cam

By Alfred S. Gutman
Mechanical Engineer
Air Force Research Center
Cambridge, Mass.

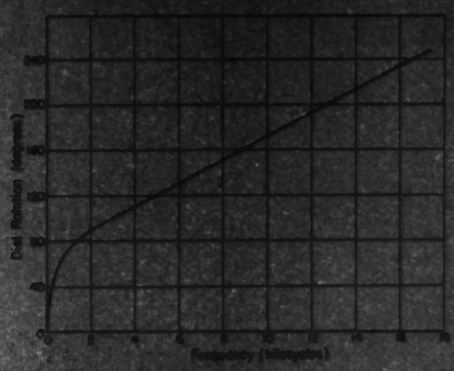


Fig. 1—Curve of output frequency versus dial rotation for a wave analyzer. Providing the inverse of this curve is the purpose of the mechanical linearizer

RECONCILING a nonlinear relationship of input to output is a frequent problem in instruments, computers and other fields of machine design, Solutions to certain problems of this sort may be provided by cams or noncircular gears as well as by four-bar linkages. Sometimes, however, these devices cannot be applied because of their inherent limitations, or application is difficult because the necessary analysis may be rather complicated.

A simplified approach, which supplements these other arrangements, is the use of a "calibration" cam in conjunction with a rack and pinion. The design briefly described in this article exemplifies this alternate solution, as applied to a problem involving the recording of wave amplitude versus frequency.

For recording output amplitude of a wave analyzer versus output frequency, a continuous-strip, direct-writing oscillograph was employed. For direct control of frequency, the wave analyzer dial, which varies the output frequency, was driven with the chart drive motor. However, since the output frequency did not vary linearly with dial rotation, the abscissa of the resulting chart would have been nonlinear. Use of this method with a wave analyzer having the calibration curve shown in *Fig.* 1 required a device to convert rotation of the oscillograph chart drive motor to a nonlinear function which would be the inverse of the dial nonlinearity. Shown in *Fig.* 2, a mechanical linearizer was used to couple the chart motor shaft and the wave analyzer dial. Thereby, uniform increments of chart length represented uniform increments of frequency.

The essential operating parts, *Fig.* 2, are an input shaft, driven by the chart motor, to which the main cam and a gear are attached rigidly; a gear and pinion on a counter-shaft which drive a pinion and a high speed or auxiliary cam at 25 times input speed; a cam follower to which a rack is attached, and a pinion to convert cam follower motion to nonlinear rotation.

The high-speed cam lifts the cam follower, or rack, over the portion of the main cam corresponding to the low frequency end of the wave analyzer dial. Pressure angle of the main cam would have been excessive over this range but the auxiliary cam, driven at 25 times main cam speed, overcomes this difficulty.

Cam contours were marked on blanks mounted on the linearizer in the same position and manner as the completed cam. A special marking tool mounted on a rack replaced the operating rack and the cams were marked with the wave analyzer dial serving as a master.

Since the linearizer operates in one direction only, backlash was of no concern. Assembly was, therefore, not highly critical and commercial quality gears could be used.

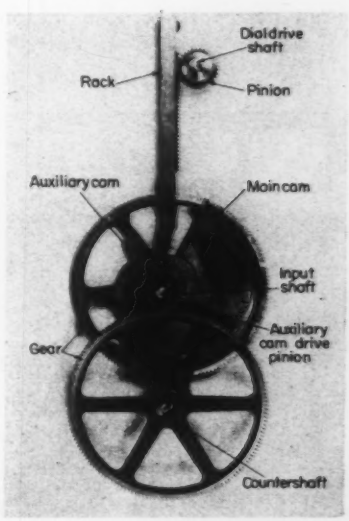


Fig. 2 — Essential components of the linearizer. Auxiliary cam provides increased mechanical advantage in the region where pressure angle of the main cam is excessively steep

QUALITY CONTROL METHODS

Only minor extension of basic SQC methods is necessary to bring them into the realm of Operations Research

Part 10—Operations Research

By Dorian Shainin
Chief Engineer
Rath & Strong Inc.
Boston, Mass.

OPERATIONS Research, as the term is used today, implies primarily the use of the scientific method of approach to a problem, including statistical analyses, trouble-shooting techniques, and adequate data obtained through effective sampling. A simple example points up a "difference" between SQC and OR: when control charts are used to point the way to better practice, instead of just as static indicators to show that conditions are no worse than they were.

". . . OR . . . can indicate solutions in . . . design and performance of a machine or product . . ."

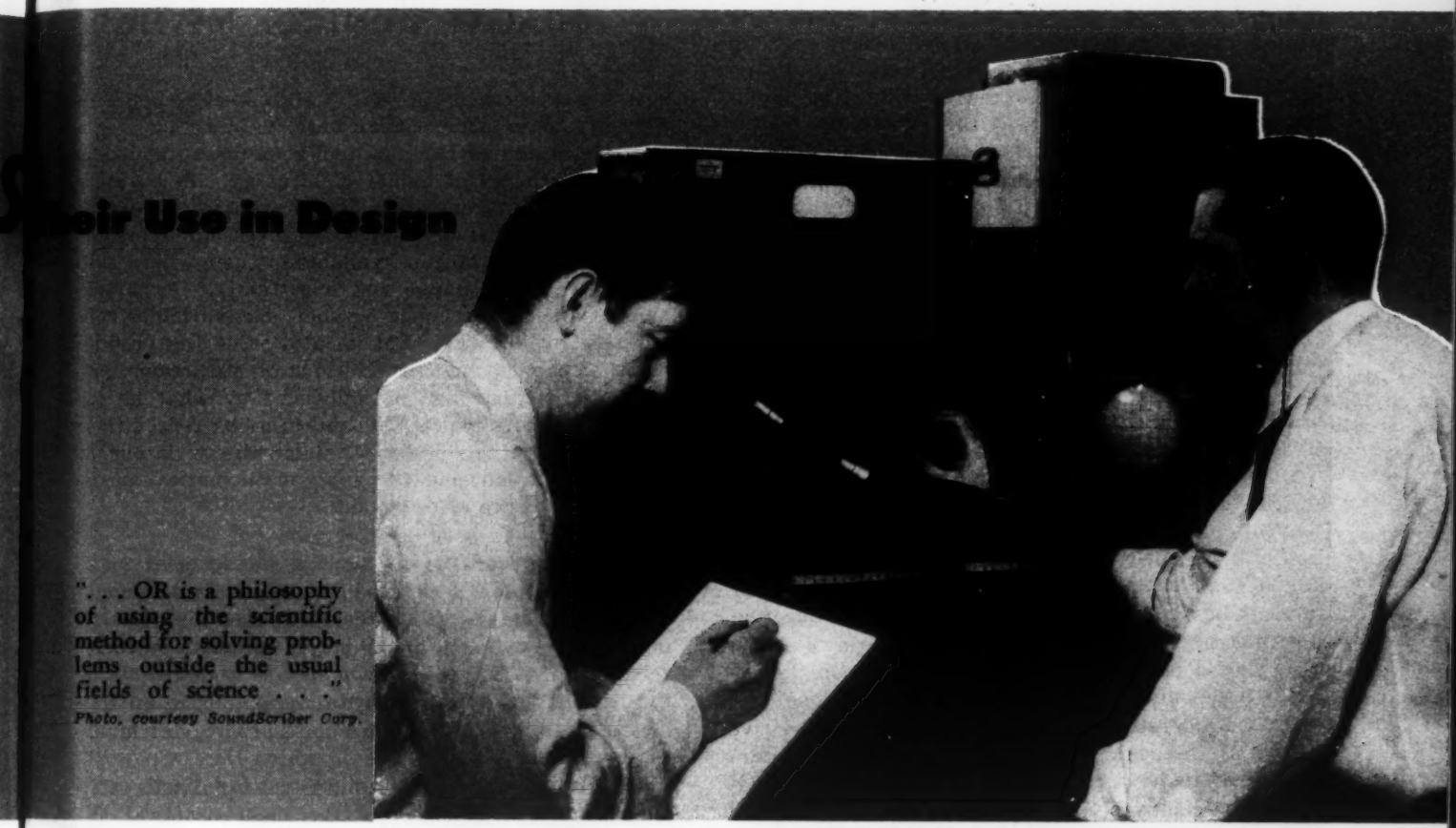
Photo, courtesy The "Flying A"

Much has been published on the subject but this presentation aims specifically to show how OR on problems of operations can indicate solutions that could have extremely fruitful results. These operational problems virtually can be of any sort. They may extend from the design and performance of a machine or product, the way to operate a process or a plant, the best selling campaign or optimum division of effort in engineering activity, through to anticipating moves a competitor may make.

Operations research, or operations analysis among other names applied to this field of endeavor, did play a successful part in many of the activities that together won World War II. The accounts of getting and analyzing data, and the tests to confirm findings excite the imagination. Currently, many stubborn industrial problems are being solved by an approach similar to OR. Formalizing information on such methodology makes good sense and present achievements may encourage some concerns to set up an OR group for trial. If properly done the plan will cost only a small portion of what it can gain.

Typical OR groups are generally teams of men

eir Use in Design



". . . OR is a philosophy of using the scientific method for solving problems outside the usual fields of science . . ."

Photo, courtesy SoundScriber Corp.

comprising unusual combinations of talents. Singularly successful results have resulted from teams made up from a few of these backgrounds: law, engineering, biology, mathematics, physics, astronomy, botany, psychology, history, sociology, and chemistry. Strangely enough they have solved problems in fields completely foreign to them: department store inventories, traffic flows, cafeteria arrangements, railroad signal systems and operating speeds, redeployment of labor, etc. They are not picked to contribute any knowledge about their field, but rather to use their particular type of thinking.

Basic OR Principles: A summary of much of the published material on OR indicates certain characteristic features. Starting with a definition that must be both general and concise, several specific features can be listed. OR is a philosophy of using the scientific method for solving operating problems outside the usual fields of science by providing quantitative bases for decisions. Considered in the light of the SQC methods discussed in the previous nine parts of this series, quality control techniques require little extension to be classed as bona fide OR activity.

However, OR is not just quality control methods applied to operating problems that may not involve quality considerations; it is something more. The definition has to be broad, and broad definitions do not differentiate. But, considering the way the problems are approached the difference becomes clear. While following ten typical procedural steps, certain underlying principles are observed, as appropriate. One authority has concisely expressed five of them as follows:

1. *Measurement.* Make measurements of the properties in which you are interested, whenever possible. Take rather extreme steps, if necessary, to devise ways to get quantitative data.
2. *Operational.* Take into account not only the operation, the equipment and the material but also the operator and the environment. Consider how they change with time and what the reactions will be under changed conditions.
3. *Feedback.* Continually review factors initially used in terms of your findings for possible alterations or substitutions. Personal contacts must be maintained among the OR team members, the executives and the operators to give every opportunity to transmit information in this cycle path.
4. *Co-operative.* Bring to bear upon the problem even more and different scientific disciplines than at first may seem needed. Each member of the OR team contributes fresh approaches that often prove invaluable.
5. *Practical.* Re-evaluate the quality and practical aspects of every phase of the research in terms of the objectives. Perform an OR upon the OR.

The ten basic procedural steps which are generally

followed are briefly enumerated in the accompanying listing. These in no way should be considered rigid in either their number or order of execution. In actual operations, they may often be carried on simultaneously as well as repeatedly through several cycles.

The OR Approach to Problems: This philosophy has a new approach toward the use of generally "old" techniques, organizing and institutionalizing scientific procedure. It works on operational problems as opposed to purely technical research. Its object is to improve the operations using the equipment available at the time. Any indicated changes to such apparatus should be considered as by-products of OR. The case history, given in some detail in Part 8, of the brazing operation with its X-ray studies is a complete OR job that ended up with such a by-product change.

Much research and development work today uses statistical methods. But decisions are often made conventionally. OR requires a conscious determination of the relative efficiency of standard procedures. For example, with the "minimax" principle usually three things must be decided: the number of observations taken, the error allowed, and the form of statistical test to be used. The first depends upon the extent of the inherent variation, the second upon economic considerations, and the test upon its relative statistical efficiency for working with the parameters considered to be pertinent. In each must be considered the seriousness of the mistakes that might come from resultant decisions as well as the probability that they will even occur. "Minimax" describes the best set of decisions in that the greatest risk necessary to take is made a small one.

A useful and rather new tool sometimes applied in OR is the theory of games of strategy. In business and industry it represents the theoretical treatment of competition between opposing forces. It appraises rationally the strategies available to them where skill is mingled with change and uncertainty. A participant in a social exchange economy has variables controllable by his will. But he also faces the product of other participants' expectations of his actions. So his initial actions will be influenced by what he expects the others expect. Their reactions reflect their expectations of his actions. Game theory is one of the steps in a movement to apply mathematical analysis to the science of economics.

Organizing for OR: In helping management make better decisions, OR works differently from commonly used aids. The OR group reports to men high enough in the organization to make major decisions by themselves. But it is *seldom given specific assignments* by the executives. OR representatives sit in on all top-level conferences. They formulate proper statements of the problems themselves on which they will work. A high order of scientific ability and familiarity with OR procedures makes this the most practical approach, unusual as it sounds. The objectives of the decision maker and of those who will use or otherwise

1. Become oriented as to the nature of the difficulty. Seek to find by yourself that a difficulty exists rather than being assigned that particular task. Do not work insulated from direct experience. Observe the operations firsthand; "there may be a better way to achieve the objective."

2. Take available data and plot them in the appropriate form, such as control charts, scatter diagrams, frequency distributions, etc. "A statistical X-ray may show the real innards of the problem."

3. Obtain new data in a planned series of experiments suggested by the revelations of step 2.

4. Identify pertinent effects. Compute the numerical degree to which they are significant, that is, could not be explained statistically as a chance variation resulting from a stable pattern of inherent variation. "Keep the gambling odds well in favor of the house."

5. Build a model, mathematical, graphical, or physical, as a picture of the possible relations. It can be simplified and idealized at this stage to make it amenable to mathematical analysis. Question and devise various measures of effectiveness of the operation as a whole to see on which the outcome most depends. Also, look for measures of outcome properties that are the most desirable. "More important than a production rate is the product of the per cent good times the production rate." Take into account countermeasures that might result from any changes that seem attractive.

6. Design a test for the hypothesis of Step 5.

7. Conduct the test and explain the dependence of the results on the several operational factors in terms of these elements: personnel, equipment, and organization of the operation. "Include a control run—is it really cause and effect?"

8. If such reductions are verifiable, the model need not be scrapped. It can be made more detailed and further predictions can be made for more experimental verification. Broader studies usually result, allowing broader predictions about outcomes under changing conditions.

9. Run new operational experiments under controlled conditions. It is sometimes appropriate to call in others in a position to judge their significance. If all runs are successful, then the optimum operation can be designed for various conditions.

10. The executive studies your conclusions of the improvements of listed magnitude that can be expected. He also considers any morale, policy or other qualitative matters that might be affected and makes decisions, which in part may have to be quite arbitrary. In some cases the optimum operation will depend upon the choice among several different measures of effectiveness. Again it is the executive's job to decide which measure shall be considered. Make sure through a follow-up that the actions decided by the executive are working out satisfactorily in practice.

be directly affected by the actions or products are first made explicit. Detected are even problems and questions of which the executive staff may be unaware. Through continuous communication with the executives, with those who will carry out the decisions, and with the recipients of the results, the OR group formulates alternative objectives. Also considered in this action are numerical measures of how apparatus and environment change with time.

In picking a man to be the nucleus of an OR team in any company, it is wise to look for one familiar with the particular problems and their implications through many years of association. He must have demonstrated his adeptness to using the scientific, rather than just a common-sense approach to solving problems. Training that will assist such a man to think statistically, in addition to some formal OR training will be highly valuable. Also, he should be given free access to all levels of activity, but his responsibility should be completely advisory in nature. It will permit him to maintain the required scientific detachment.

OR solutions are not necessarily mixed with complex methods of analysis. Sometimes a single man, with a multiple-type background, can act as will an OR team. He should be able to call in one or more specialists if he needs them or make permanent additions to his staff.

If suitable personnel are not available it is possible to call in a group of OR consultants. It should be obvious, however, from the methodology and relationships that make OR an effective philosophy that using a consulting group alone can never be as worthwhile as integrating the group into the organization.

OR For Machine Design: A complex machine design problem may well benefit from OR. The energy now spent groping with innumerable details could be replaced by the efforts of an OR team. In developing a new piece of equipment, OR can first analyze the operating environment. The available input conditions and the desired output results can be determined. These measures of effectiveness are often different from and better than what the customer ordered! Thus the minimum characteristics of each component of the design are established. In many cases statistical probability models could well be set up for the operation of the entire machine or for any of its parts. OR might compute the probability of success of the assembled apparatus, and let the design details be guided to make that a maximum. New and better methods of handling new design problems will undoubtedly be devised from this sort of approach.

An activity that helped save lives and win battles during the war could find still another interesting and profitable industrial task.

BIBLIOGRAPHY

1. P. M. Morse and G. E. Kimball—*Methods of Operations Research*, The Technology Press, M.I.T., and John Wiley & Sons Inc., New York, 1951.
2. National Research Council Committee on Operations Research—*Operations Research with Special Reference to Non-military Applications*, N.R.C., 2101 Constitution Avenue, Washington, D. C., 1951.
3. J. von Neumann and O. Morgenstern—*Theory of Games and Economic Behavior*, Princeton University Press, 1947.
4. Case Institute of Technology, Cleveland, Ohio, *Proceedings of the First Seminar in Operations Research*, 1951.
5. Russell L. Ackoff—"Operations Research in Business and Industry," *Industrial Quality Control*, Vol. VIII, No. 6, May, 1952.
6. Wade R. Weaver—"Operations Research and Its Relationship to Quality Control," Republic Steel Corp., Cleveland, Ohio, 1952.

"Quality Control" Reprinted

Owing to the large number of requests for the articles, "Quality Control Methods—Their Use in Design," by Dorian Shainin, the entire series of ten parts have been reprinted under one cover. This 64-page booklet is available at one dollar per copy, with discounts on quantity orders, from the Book Dept., Penton Publishing Co., Cleveland 13, Ohio.

Characteristics of a Research Director

FIRST essential step of inestimable importance in organizing a research department is the selection of a good director as part of top management. Since invention and research is a mental and psychological activity, it is more important than with any other executive that the research director possess the right qualities of leadership. Any organization, large or small, is but the extended shadow of its management or of a single dominant personality in the company. What then are the desired characteristics of the successful and efficient executive?

1. He must be liked.
2. He must be respected as a person and as the director.
3. He must have enthusiasm for his work and the ability to transmit this enthusiasm up and down the line—and sideways, too.
4. He must be a good salesman of himself to the rest of the management as well as to his particular department.

It is notable that scholarship and technical knowledge are not stressed as requisites of good administration.

Abstracted from "Planned Invention" by Hal F. Fruth, Tenth Annual Machine Design Conference, Cleveland Engineering Society, Feb., 1953.

Determining MOMENTS OF INERTIA of nonsymmetrical components

By William E. Soong
Development Engineer
Streeter-Amet Co.
Chicago, Ill.

IN THE design of a component for a low-speed machine, the inertia load due to acceleration is often of negligible importance. However, in a high-speed machine, particularly in a high-speed oscillating mechanisms such as sometimes employed in servomechanisms, the inertia loads should be carefully analyzed for an optimum design.

Mass moments of inertia can be obtained from the integral form

$$J = \int y^2 \, dm \qquad (1)$$

By definition Equation 1 gives the moment of inertia of a mass m, and it can be used for any mass to which the process of integration can be applied. For example, in *Fig.* 1 the mass moment of inertia of the hollow right-circular cylinder rotating about its axis AA can be found by integration of Equation 1:

$$J = m \frac{R^2 + r^2}{2}$$

where

$$m = \frac{w}{g} = \frac{\pi h D}{g} (R^2 - r^2)$$

from which a general form can be written

$$J_n = \frac{\pi h D}{2g} (r_n^4 - r_{n-1}^4) \qquad (2)$$

However, many machine parts have shapes or forms for which the direct process of integration cannot be used. Suppose it is desired to calculate the mass moment of inertia of a bellcrank with a uniform thickness or height h rotating about its axis as shown in *Fig.* 2. The bellcrank can be divided into circular sections or rings at convenient intervals by a series of concentric circles. Ring 1 has no weight and thus no moment of inertia because it is the hole. The section in ring 2 is a right-circular cylinder and its moment of inertia can be calculated from Equation 2. There are two sections in ring 3 contained between arcs of two circles with radii r_2 and r_3. Between these two arcs a mean arc a_3 on arm A and a mean arc b_3 on arm B can be drawn with their respective angles α_3 and ϕ_3. These angles can be measured and the sum of their values θ_3 can be recorded. The moment of inertia of the sections under consideration

Nomenclature

D	= Density, lb per cu in.
J	= Mass moment of inertia, lb-in. per sec^2
f	= $(r_n^4 - r_{n-1}^4)$, in.^{4}
g	= Gravitational acceleration constant, 386 in. per sec^2
h	= Height or thickness, inches
m	= Mass, lb-sec^2 per in.
r_n	= Outside radius of nth ring, inches
r_{n-1}	= Inside radius of nth ring, inches
w	= Weight, lb
y	= Distance between axis of rotation and centroid of mass dm, inches
θ	= Summation of the mean angles of sections in the nth ring, deg

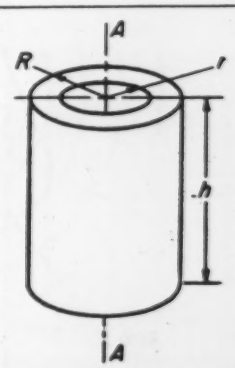


Fig. 1—A hollow right-circular cylinder rotating about its axis AA has a mass moment of inertia, $J = m\,(R^2 + r^2)/2$

in this ring is determined by multiplying Equation 2 by $\theta_3/360$ or

$$J_3 = \frac{\pi\,\theta_3\,hD}{720\,g}\,(r_3^4 - r_2^4)$$

This procedure is repeated for the sections in ring 4, etc. The total mass moment of inertia of the bellcrank is the summation of the mass moments of inertia in the six rings. Obviously, the closer together the circles are drawn, the more accurately the total mass moment of inertia is evaluated.

In summary, the moment of inertia for a nonsymmetrical machine part can be determined by dividing it into several ring-shaped sections by a series of concentric circles. The moment of inertia of the portion a part occupies under each ring is

$$J_n = \frac{\pi}{720\,g}\,\theta_n\,hDf \qquad (3)$$

where $f = r_n^4 - r_{n-1}^4$. The values for all rings are summed, giving the total moment of inertia of a part with a given density and shape. Densities of common engineering materials are: steel, 0.2820 lb per cu in.; brass, 0.3030; and aluminum, 0.0924.

It is necessary to calculate the thickness-density product hD only once for a uniform-thickness part or component. Values of f are tabulated in TABLE 1 for three different radial increments over ranges which are likely to embrace most practical situations. After hD and f are tabulated for each ring, the successive J values can be evaluated. Quick and accurate J determinations for each ring can be made with the nomogram in *Fig.* 3, which is a graphical solution of Equation 3.

As an example, the mass moment of inertia can be determined for a cylindrical or ring-shaped section of steel with $r_n = 3.7$ inches, $r_{n-1} = 3.6$ inches, $h = 1.75$ inches, and $\theta = 300$ deg.

The thickness-density product $hD = 1.75\ (0.282) = 0.4935$. The value of f from the 0.1-increment column of TABLE 1 for $r_n = 3.7$ inches is 19.4545. In *Fig.* 3 the answer is obtained by drawing a line from $hD = 0.4935$ to $\theta = 300$. From the intersection of this line with the turning axis q draw a line to $f = 19.4545$. The resulting intersection at the J scale gives $J = 0.032479$ lb-in. per sec^2.

Fig. 2—Moment of inertia of a bellcrank with uniform thickness can be determined by dividing it into several ring-shaped sections. Moments of sections under all rings are calculated and summed

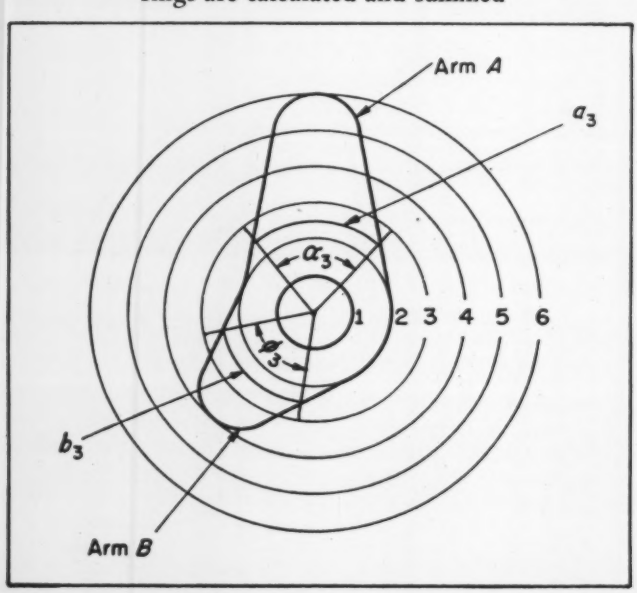


Table 1—Radius Factors

Increments 0.1		0.2		0.5	
0.0	0.0000	2.0	5.5024	5.0	214.9375
0.1	0.0001	2.2	7.4740	5.5	290.0625
0.2	0.0015	2.4	9.7036	6.0	380.9375
0.3	0.0065	2.6	12.5200	6.5	489.0625
0.4	0.0175	2.8	15.7680	7.0	615.9375
0.5	0.0369	3.0	19.5344	7.5	763.0625
0.6	0.0671	3.2	23.8576	8.0	931.9375
0.7	0.1105	3.4	28.7760	8.5	1124.0625
0.8	0.1695	3.6	34.3280	9.0	1340.9375
0.9	0.2465	3.8	40.5520	9.5	1584.0625
1.0	0.3439	4.0	47.4864	10.0	1854.9375
1.1	0.4641	4.2	55.1696	10.5	2155.0625
1.2	0.6095	4.4	63.6400	11.0	2485.9375
1.3	0.7825	4.6	72.9360	11.5	2849.0625
1.4	0.9855	4.8	83.0960	12.0	3245.9375
1.5	1.2209	5.0	94.1584	12.5	3678.0625
1.6	1.4911	5.2	106.1616	13.0	4146.9375
1.7	1.7985	5.4	119.1440	13.5	4654.0625
1.8	2.1455	5.6	133.1440	14.0	5200.9375
1.9	2.5345	5.8	148.2000	14.5	5789.0625
2.0	2.9679	6.0	164.3504	15.0	6419.9375
2.1	3.4481	6.2	181.6336	15.5	7095.0625
2.2	3.9775	6.4	200.0880	16.0	7815.9375
2.3	4.5585	6.6	219.7520	16.5	8584.0625
2.4	5.1935	6.8	240.6640	17.0	9400.9375
2.5	5.8849	7.0	262.8624	17.5	10,268.0625
2.6	6.6351	7.2	286.3856	18.0	11,186.9375
2.7	7.4465	7.4	311.2720	18.5	12,159.0625
2.8	8.3215	7.6	337.5600	19.0	13,185.9375
2.9	9.2625	7.8	365.2880	19.5	14,269.0625
3.0	10.2719	8.0	394.4944	20.0	15,409.9375
3.1	11.3521	8.2	425.2176	20.5	16,610.0625
3.2	12.5055	8.4	457.4960	21.0	17,870.9375
3.3	13.7345	8.6	491.3680	21.5	19,194.0625
3.4	15.0415	8.8	526.8720	22.0	20,580.9375
3.5	16.4289	9.0	564.0464	22.5	22,033.0625
3.6	17.8991	9.2	602.9296	23.0	23,551.9375
3.7	19.4545	9.4	643.5600	23.5	25,139.0625
3.8	21.0975	9.6	685.9760	24.0	26,795.9375
3.9	22.8305	9.8	730.2160	24.5	28,524.0625
4.0	24.6559	10.0	776.3184	25.0	30,324.9375
4.1	26.5761	10.2	824.3216	25.5	32,200.0625
4.2	28.5935	10.4	874.2640	26.0	34,150.9375
4.3	30.7105	10.6	926.1840	26.5	36,179.0625
4.4	32.9295	10.8	980.1200	27.0	38,285.9375
4.5	35.2529	11.0	1036.1104	27.5	40,473.0625
4.6	37.6831	11.2	1094.1936	28.0	42,741.9375
4.7	40.2225	11.4	1154.4080	28.5	45,094.0625
4.8	42.8735	11.6	1216.7920	29.0	47,530.9375
4.9	45.6385	11.8	1281.3840	29.5	50,054.0625
5.0	48.5199	12.0	1348.2224	30.0	52,664.9375
5.1	51.5201	12.2	1417.3456	30.5	55,365.0625
5.2	54.6415	12.4	1488.7920	31.0	58,155.9375
5.3	57.8865	12.6	1562.6000	31.5	61,039.0625
5.4	61.2575	12.8	1638.8080	32.0	64,015.9375
5.5	64.7569	13.0	1717.4544	32.5	67,088.0625
5.6	68.3871	13.2	1798.5776	33.0	70,256.9375
5.7	72.1505	13.4	1882.2160	33.5	73,524.0625
5.8	76.0495	13.6	1968.4080	34.0	76,890.9375
5.9	80.0865	13.8	2057.1920	34.5	80,359.0625
6.0	84.2639	14.0	2148.6064	35.0	83,929.9375
6.1	88.5841	14.2	2242.6896	35.5	87,605.0625
6.2	93.0495	14.4	2339.4800	36.0	91,385.9375
6.3	97.6525	14.6	2439.0160	36.5	95,274.0625
6.4	102.4255	14.8	2541.3360	37.0	99,270.9375
6.5	107.3409	15.0	2646.4784	37.5	103,378.0625
6.6	112.4111	15.2	2754.4816	38.0	107,596.9375
6.7	117.6385	15.4	2865.3840	38.5	111,929.0625
6.8	123.0255	15.6	2979.2240	39.0	116,375.9375
6.9	128.5745	15.8	3096.0400	39.5	120,939.0625
7.0	134.2879	16.0	3215.8704	40.0	125,619.9375
7.1	140.1681	16.2	3338.7536	40.5	130,420.0625
7.2	146.2175	16.4	3464.7280	41.0	135,340.9375
7.3	152.4385	16.6	3593.8320	41.5	140,384.0625
7.4	158.8335	16.8	3726.1040	42.0	145,550.9375
7.5	165.4049	17.0	3861.5824	42.5	150,843.0625
7.6	172.1551	17.2	4000.3056	43.0	156,261.9375
7.7	179.0865	17.4	4142.3120	43.5	161,809.0625
7.8	186.2015	17.6	4287.6400	44.0	167,485.9375
7.9	193.5025	17.8	4436.3280	44.5	173,294.0625
8.0	200.9919	18.0	4588.4144	45.0	179,234.9375

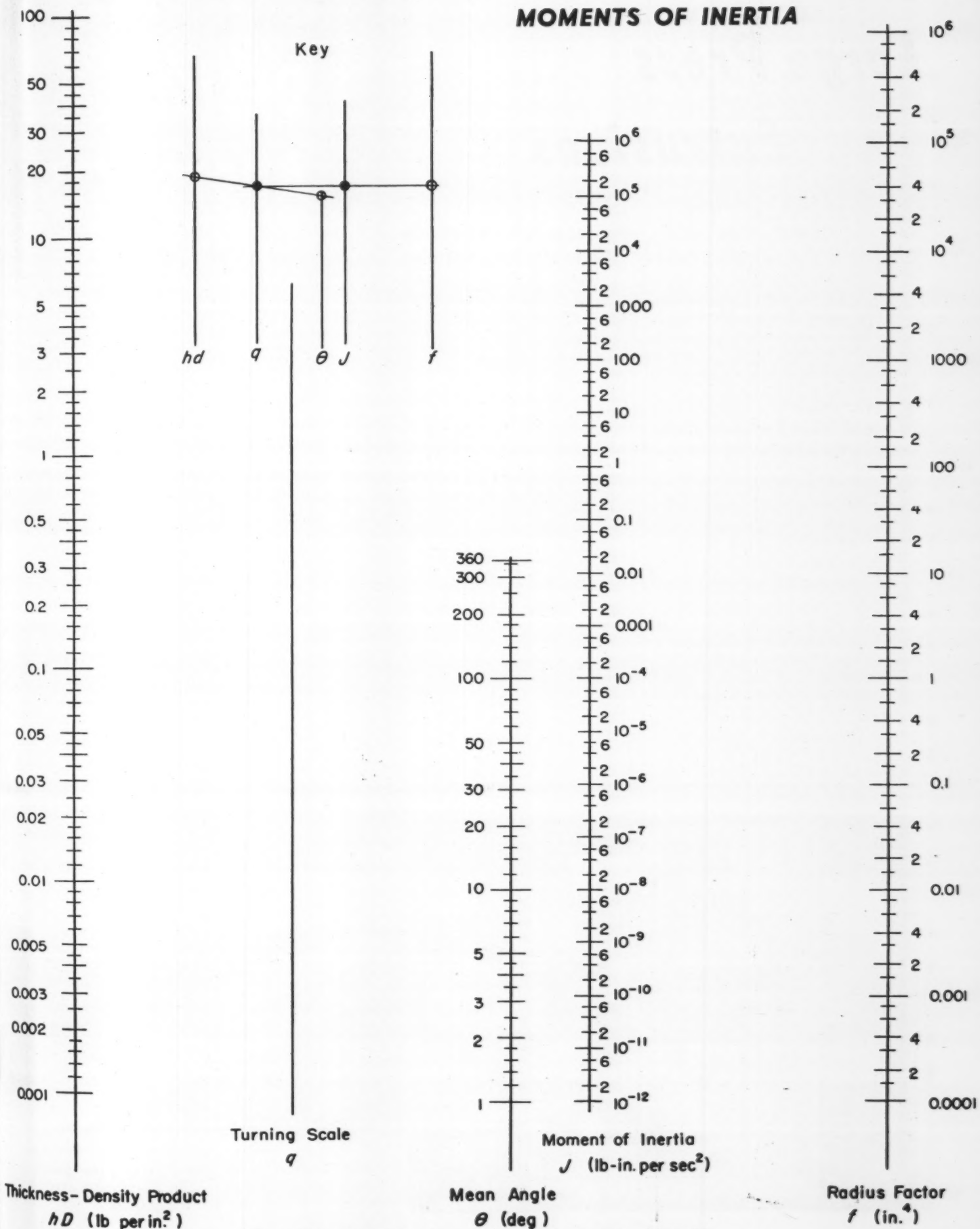


Fig. 3—Nomogram for determining mass moments of inertia

Large Press Extrusions

DESIGN ABSTRACTS

. . . extend size and intricacy of available shapes and provide greater fabrication economies

By T. F. McCormick
Metallurgist
Aluminum Company of America
Pittsburgh, Pa,

EXTRUSION is a comparatively new manufacturing method largely developed within the present century for the fabrication of wrought metal shapes and tubes. In a relatively short period it has become established as one of the most important methods for manufacturing widely used shapes, *Fig.* 1, particularly in the light-metal industry.

Giant presses now under construction or planned in this country will enlarge by severalfold the size of lightmetal shapes and tubes that may be extruded. The operation of the new presses will present many production problems, both predicted and unpredicted, but at the same time will permit the extrusion of large or intricate shapes which lead to economy and versatility in aircraft construction.

The largest extrusion press in operation in this country today has a rated capacity of 5500 tons. The size most commonly used for producing the types of extrusions used in aircraft is the 2500-ton press. There is a distinct break between the ingot sizes used and the extrusions produced with 2500 and 4000-ton presses. On this basis a press with a rated capacity of 4000 tons or more can be considered a large extrusion press.

Extrusion Equipment: With few exceptions the extrusion presses used in this country today for producing lightmetal extruded shapes and tubes are of the horizontal rather than vertical type, operate by pressure applied hydraulically, and employ the direct method of extrusion. The usual limit of extruded shapes with present presses is about 600 pounds.

The first of the very large extrusion presses under the United States Air Force program, which will begin operation about the middle of 1953, has a rated capacity of 13,200 tons—two and a half times greater than equipment now

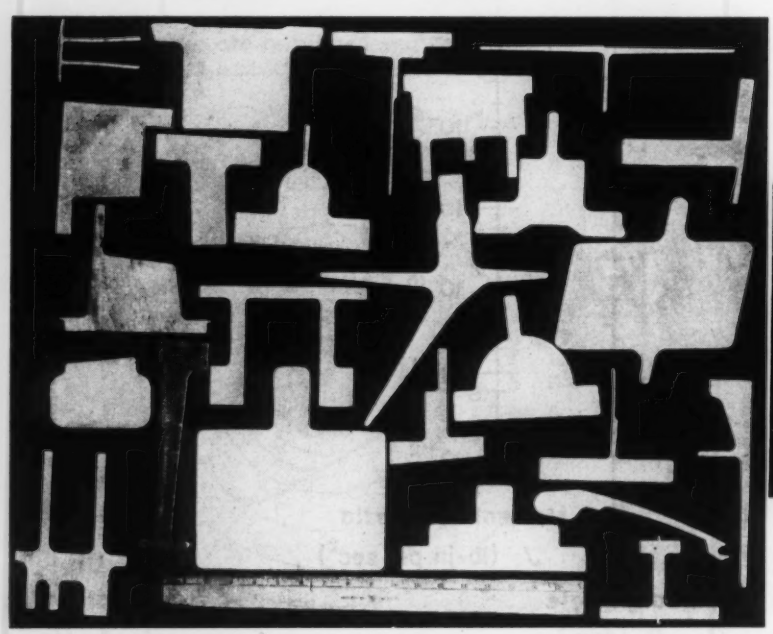


Fig. 1—Left—Typical of present large press capabilities, these extruded shapes will be further extended in size and intricacy by the new and larger presses now being built

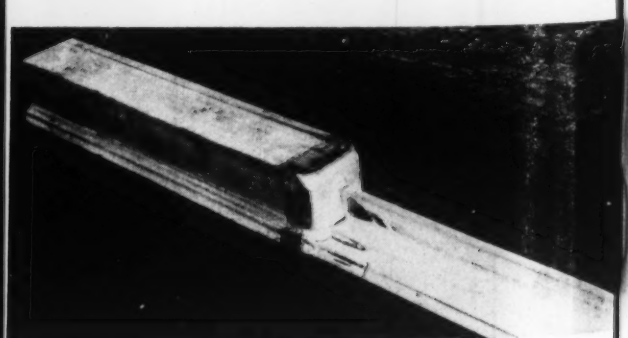


Fig. 2—Above—A typical large press product, the stepped extrusion has found extensive use for wing spars

Table 1—Minimum Thickness of Extruded Solid Shapes*

Circumscribing Diameter (in.)	Aluminum Alloy 3S-63S (in.)	61S-62S (in.)	14S (in.)	24S-75S (in.)
Under 13	0.093	0.109	0.125	0.156
13 to 16	0.109	0.125	0.156	0.187
16 to 19	0.125	0.140	0.171	0.250
19 to 23	0.140	0.156	0.187	0.375

*13,200 ton press. Minimums given are not absolute and can vary depending on the shape.

in operation. Contemplated manufacturing limits for solid shapes produced with this press, and its planned auxiliary equipment, have been established with a maximum length of heat-treated aluminum alloy extrusion of 90 feet, a maximum weight of 2300 pounds and a maximum cross section to fit within a circumscribing circle having a diameter of 23 inches. Such units cannot be stated on an absolute basis and under certain conditions they may be exceeded. Tubes and certain hollow shapes of larger diameter are a distinct probability. The minimum thickness for the average shape which can be extruded in several aluminum alloys is shown in TABLE 1.

Diemaking in the extrusion industry is considered an art, although extensive experimental work has been conducted to establish engineering principles, ascertain working formulas, and set up die design on a scientific basis. Much has been accomplished but it is not yet possible to design and build a die for a complicated shape with complete assurance that it will produce a usable extrusion the first time it is tried. Dies for many nonsymmetrical shapes may be tried and altered several times before a satisfactory extrusion is obtained, particularly with dies for large presses. Making extensive alterations is expensive, time consuming of press and manpower and wasteful of ingot stock. Fortunately, enough is known about die building that it is rarely necessary to construct a new die in order to make the required alteration.

The production of stepped extrusions, *Fig.* 2, used extensively for aircraft wing spars is almost exclusively a feature of the large press. A die to produce a stepped extrusion is constructed with several parts. Certain parts of the die may be replaced with others providing larger openings at one or more stages during extrusion. Higher than normal extrusion pressure requirements are dictated in order to permit extrusion of an initial small section and provide sufficient cylinder size for adequate extrusion ratio for the larger final section.

Extrusions tapered from end to end have received consideration from several experimenters. It is generally conceded that the best method of producing tapered sections is to group a number of them in a symmetrical design around a mandrel so contoured as to produce the desired taper. Production of this type of section is limited with present extrusion presses, but the very large presses will make the method more attractive.

Mandrels for hollow shapes and tubes generally contain a slight taper. Thus the inside diameter of a tube will be slightly smaller at the start of extrusion than at the finish. The amount of this taper has been substantially decreased during recent years and it is now possible to produce extruded tubes to close dimensional tolerances, whereas previously it was considered necessary to utilize cold drawing for a sizing operation. This development has markedly decreased the cost of lightmetal

(*Continued on Page* 276)

Fig. 3—Typical strength curves for 75S-T6 extrusions show effect of variations in cross-sectional area which must be recognized in design

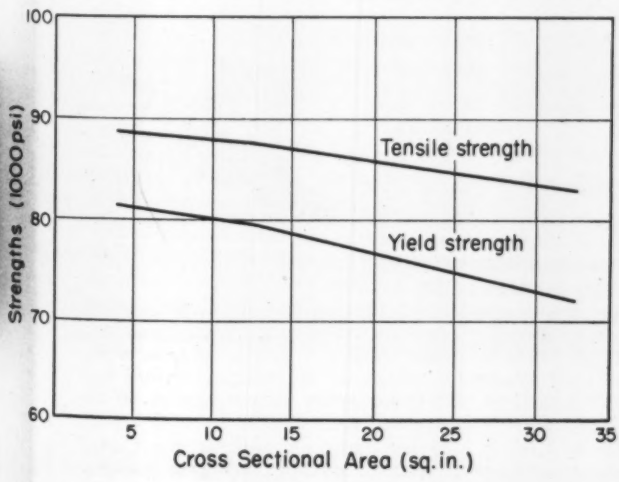
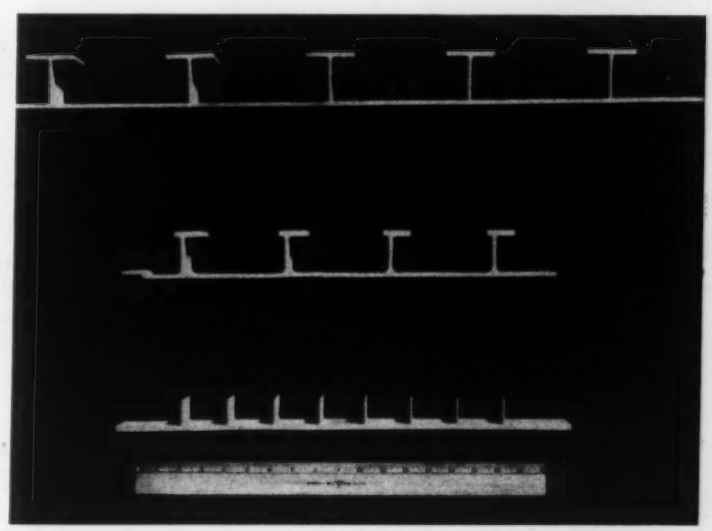


Fig. 4—Integrally rib-stiffened aircraft wing panels are readily extruded but difficulties encountered in straightening the panels have placed limits on available sizes



NEW PARTS

CONDUCTIVE SPRING MATERIAL 1

. . . has excellent ductility

General Plate Div., Metals and Controls Corp., Attleboro, Mass.

High ductility permits easy forming and subsequent heat treating produces good spring characteristics.

Designation: Conflex.

Size and Form: Strips up to 8 in. wide and 0.050-in. or less in thickness.

Service: Easily formed to required shape; electrical conductivity may be varied; easily electroplated.

Properties: Hardenable steel clad with electrolytic copper on one or both sides; conductivity of strip clad on both sides with 10:80:10 thickness ratio is better than 30 per cent of that of solid copper.

Applications: Fuse clips; blade or spiral type springs; electrical connectors.

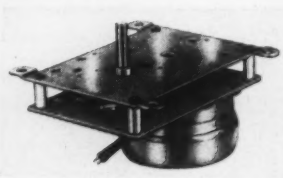
For more data circle MD 1, Page 213

TIMING MACHINE 2

. . . produces intermittent motion

Hansen Mfg. Co. Inc., Princeton, Ind.

Four designs produce three, four, five, or six stop-and-go motions per revolution.



Designation: Stop-N-Go.

Size: Base, 2 by 3¼ in.

Service: Providing intermittent motion; power, 8 oz-in. at 1 rpm; used in controlling on-off action with precision snap-action switches; gives constant speed throughout motion period; has quick resumption to full turning speed from standstill; total period of immobility is twice time taken for motion; number of stop-and-go intervals per revolution is determined by speed of motor.

Design: Motor, gear train and intermittent gear.

For more data circle MD 2, Page 213

THERMOCOUPLE PROTECTING TUBES 3

. . . use less nickel than previous types

Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Philadelphia 44, Pa.

Though these tubes use half as much nickel as previous types, they will withstand extremely high temperatures.

Size: ½ or 1 in. pipe size; lengths to 60 in. in 6 in. increments.

Service: Protecting thermocouples; approved by the NPA for use in reducing atmospheres over 900 F and for neutral or oxidizing atmospheres over 1400 F; rated by Honeywell engineers at 1900 F.

Design: Incoloy tubing; tubing is drawn and the end is plugged and welded; composition is similar to Chromel-T.

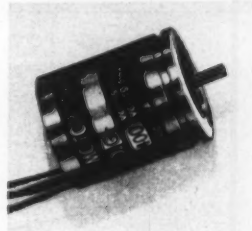
For more data circle MD 3, Page 213

PRECISION SERVOMOTOR 4

. . . for small-torque control applications

G-M Laboratories Inc., 4300 N. Knox Ave., Chicago 41, Ill.

These motors can be supplied to meet rigid military specifications.



Designation: Miniature.

Size: 0.98 in. diam, 1.30 in. long.

Service: For applications in gunfire controls, guided missiles, aircraft controls, rocket controls, and industrial controls; meet military specifications with regard to humidity, temperature, vibration, and altitude; available for frequencies varying from 60 to 400 cps; stall torque ranges from 0.25 to 0.35 oz-in.

Design: 2, 4, or 8-pole construction; output shaft can be supplied to suit, with or without integral pinion; tolerances in motor as small as ±0.0001 in.

For more data circle MD 4, Page 213

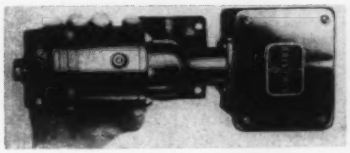
NEW PARTS

PNEUMATIC TRANSMITTER 5

. . . will operate in any position

Bristol Co., Waterbury 20, Conn.

Air pressure variations are transmitted through tubing to receiver instrument up to 1000 feet away.



Designation: Series 650.

Size: 12¼ in. high, 6 in. deep; weight, 7½ lb.

Service: For measuring and transmitting readings of temperature, pressure, vacuum, differential pressure and liquid level to recording, indicating, and controlling receivers; measuring element in transmitter converts variations of input quantity into proportional outlet air pressure; outlet air pressure varies from 3 psi for minimum input to 15 psi for maximum input; sensitivity, 0.03% of full range input; available in wide selection of ranges for measuring pressure from 0-5 in. water to 0-10,000 psi, vacuum from 0-5 in. water to full vacuum, temperature from −100 F to 1000 F, liquid level from 0-5 in. water and up, and differential pressure from 0-2 in. water to 0-500 in. water.

Design: Uses standard Bristol measuring elements connected directly to frictionless air pilot which varies a booster valve.

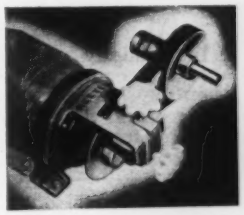
For more data circle MD 5, Page 213

VARIABLE SPEED UNIT 7

. . . inexpensive to install and maintain

Reeves Pulley Co., Columbus, Ind.

Unit combines flexibility in operation and application.



Designation: Flexi-Speed.

Size: Minimum pitch diam, 1⅞ in.; maximum pitch diam, 5⅝ in.; bore diam, ⅝ and ¾-in. with $\frac{3}{16}$ by $\frac{3}{32}$-in. keyway;

No.	Width (in.)	Height (in.)	Depth (in.)
20-66	8¼	$8\frac{3}{16}$	$8\frac{3}{8}$
20-203	10	$9\frac{13}{16}$	$8\frac{3}{8}$

Service: Providing a variable-speed for ½, ¾ or 1 hp electric motors; may be mounted in almost any position around driven shaft; operates in either direction; delivers any desired speed within a ratio of 8 to 1; speed control handwheel may be located parallel to or in any of eight positions perpendicular to the motor shaft; adaptable to in-line or right-angle reducers, countershafts and chain, sprocket, or V-belt drives.

Design: Variable-pitch hand-adjusted pulley with mount which is fastened with ⅜-in. bolts.

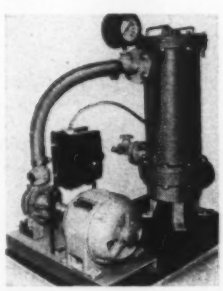
For more data circle MD 7, Page 213

FILTER PUMPS 6

. . . for corrosive solutions

Sethco, 70-78 Willoughby St., Brooklyn 1, N. Y.

Pump and all fittings are fabricated of corrosion-resistant stainless steel.



Designation: RLS Series.

Size: Model RLS-1200 and 2400, 3 ft wide, 3½ ft high, 2 ft deep; Model RLS-1200 rated at 1000 to 1500 gph; Model RLS 2400 rated at 2000 to 2500 gph.

Service: Filtering practically any acid or alkaline solution from pH 1 to pH 14; has pressure gage which shows psi in filter assembly; has pressure switch which automatically shuts off pump motor when pressure in filter system reaches 40 psi; uses drip-proof 220 or 440 v 3 phase motors, Model RLS-1200 uses 1 hp motor and Model RLS-2400 uses 2 hp motor; furnished with 15-foot inlet and outlet chemical hose.

Design: Type 316 stainless steel pump and fittings; pump, positive displacement type; filter assembly is rubber lined; base equipped with heavy ball-bearing, rubber-covered casters; cotton, Dynel, Orlon, nylon, spun glass, porous stone or porous carbon filters.

For more data circle MD 6, Page 213

ACCELEROMETER 8

. . . hermetically sealed in inert gas

G. M. Giannini & Co. Inc., 117 E. Colorado St., P.O. Box N, Pasadena, Calif.

Instrument features compactness and long life.

Designation: 24132.

Size: 3.34 in. long, 2.43 in. wide, 3.12 in. high; weight, 3½ lb.

Service: For any acceleration measurement up to 30g; has low natural frequency and large output requiring no amplifying unit in most applications; utilizes potentiometer resistance, available in ranges from 1000 to 20,000 ohms; potentiometer element carries current up to 10 ma; minimum resolution, 0.25%; optimum operation obtained between −54 C and +71 C; damping for 7.5g instrument, 0.5 ±0.075 of critical.

Design: Potentiometer resistance accelerometer; hermetically sealed; magnetic damping; special shipping stop obtainable for increasing instrument life.

Applications: Computers, telemetering, and aircraft and missile control.

For more data circle MD 8, Page 213

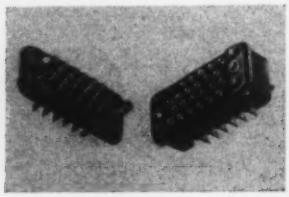
NEW PARTS

ELECTRICAL CONNECTORS 9

. . . eliminate pulling or prying to separate

DeJur-Amsco Corp., Industrial Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

Individually spring-loaded contact pins require low connecting force and no disengagement force.



Designation: E-Z 16.

Size: Receptacles are $\frac{53}{64}$-in. thick excluding mounting stud length; widths vary from $\frac{5}{8}$ to $1\frac{1}{8}$ in., lengths from $2\frac{5}{16}$ to $3\frac{13}{32}$ dependng on number of pins; for No. 16 AWG wire; plugs have same dimensions as receptacles except thickness is $\frac{13}{32}$-in.

Service: Easily engaged and disengaged; cannot be improperly connected; 10 amp current capacity; 6500 v dc breakdown voltage at sea level; 1500 v dc breakdown voltage at 60,000 ft; temperature range of −55 to 85 C.

Design: 12, 18, 24 or 34 pin connectors; polarizing guide pins; bodies molded of mineral-filled melamine; contacts of phosphor bronze, silver plated and gold flashed; available in Plaskon type 440 A or diallylphthalate (blue), if desired.

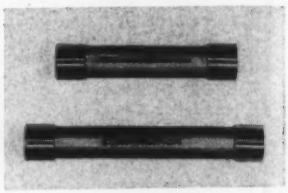
For more data circle MD 9, Page 213

SELENIUM RECTIFIER CARTRIDGES 11

. . . easily mounted or replaced

International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Installation or removal of these rectifier cartridges is extremely simple as they are both mounted and connected by insertion into standard 30 amp fuse clips.



Designation: V75HF, V100HF

Size: Both $\frac{9}{16}$-in. diam; V75HF is $3\frac{1}{4}$ in. long; V100HF is $4\frac{5}{32}$ in. long.

Service: V75HF delivers 5 ma to capacitive load at 1500 v dc; V100HF delivers 5 ma load to capacitive load at 2000 v dc; meet JAN specifications for humidity, shock, vibration and altitude; for temperatures from −65 to 100 C; flat frequency response to 8000 cps.

Design: Rectifier cartridges composed of sufficient 26 v cells to make up required voltage.

Applications: Computers; electrostatic precipitators; radar and television circuits.

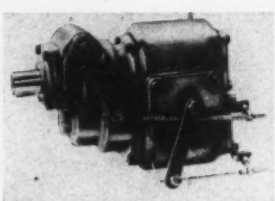
For more data circle MD 11, Page 213

POWER TAKEOFF 10

. . . can be adapted to any truck transmission

Chelsea Products Inc., Chelsea, Mich.

Developed to drive accessory equipment at speeds slower than previously obtainable; low speed ratio is 36 per cent of that of the standard model.



Size: 12 by $7\frac{3}{4}$ by $6\frac{3}{4}$ in.; weighs 48 lb; $\frac{13}{16}$, 1, $1\frac{1}{8}$ or $1\frac{1}{4}$ in. diam output shaft.

Service: Two speeds forward and two in reverse; high forward equals speed of drive gear in transmission times number of teeth in gear divided by 20.8; low forward, divide by 57.7; high reverse, divide by 16.1; low reverse, divide by 44.7; rated torque, 150 lb-ft.

Design: Main housing is malleable iron; reduction gear box is aluminum; all gears and shafts of alloy steel; all gears are helical; uses tapered roller and cageless roller bearings; interchangeable drive gears for adaptation to various makes of transmission; engagements and shifting by short stroke sliding clutches controlled by bowden wires.

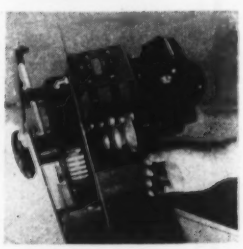
For more data circle MD 10, Page 213

MOTOR-OPERATED RHEOSTAT 12

. . . utilizes standard rheostat plates

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

One to three 8 or 13-in. diam rheostat plates can be operated by this control.



Designation: Type RK.

Size: Mounting panel is 15 by 15 in.; drive extends $8\frac{3}{4}$ in. in front of panel; maximum extension at rear of panel is 11 in., using three 13 in. diam plates.

Service: Varying field resistance to control speed of dc motors to 200 hp and voltage of generators to 300 kw; time for full rheostat travel may be in 5 to 15-second or 15 to 45-second range; travel time may be adjusted within these ranges; all components readily accessible; for 115 or 230 v dc operation.

Design: Dc motor and speed reducer, jaw coupling, spring clutch and 2 to 4 limit switches mounted on square steel plate; cam drum for actuation of limit switches on reducer output shaft; cams adjustable over 360-degree range; cams available for 15, 45 and 90 degree travel; motor may be series or compound-wound type.

For more data circle MD 12, Page 213

NEW PARTS

BLIND RIVETS 13

. . . for light assembly work

Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.

It is claimed that one man can install more than one thousand of these rivets per hour.

Designation: HR-J3-2N.

Size: Length of rivet proper is $\frac{5}{32}$-in. before installation; for 0.093 to 0.096-in. holes; grip range of 0.015 to 0.203-in.

Service: For light assembly work; resist corrosion; easily installed; cannot loosen; have good shear and tensile strength.

Design: Pull-through type blind rivet; rivet is nickel-plated brass; pull-through pin of mild steel; pulling pin through rivet expands projecting portion of rivet on blind side to form head and also expands rivet to fill hole; rivet pull gun required for installation.

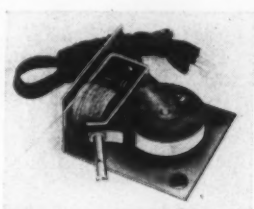
For more data circle MD 13, Page 213

IMPULSE MOTOR 14

. . . has vernier speed control

General Die and Stamping Co., 262 Mott St., New York 12, N. Y.

Speed may be varied steplessly over a range in excess of 150 to 1.



Designation: Kasson Vibramotor, Model AV or BV.

Size: Model AV is 2 in. high, 4 in. long and 5¼ in. wide, weighs 1½ lb; Model BV is 2½ in. high, 4½ in. long and 5¾ in. wide, weighs 2½ lb.

Service: Operates on 110 v 60 cps ac; power requirement is 9 w; speed range of AV is from 1 to 250 rpm; starts and stops instantly when power is removed or applied.

Design: Constructed of steel stampings and screw machine parts except that pulley is nonferrous die casting; BV is same as AV except for reduction gears; thumb nut varies speed; may be mounted in any position.

Applications: Electrical controls; laboratory apparatus; alarm systems.

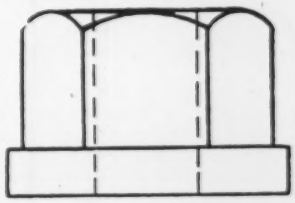
For more data circle MD 14, Page 213

ACORN NUTS 15

. . . contact surface square with thread

Reid Tool Supply Co., 709 Baker St., Muskegon Heights, Mich.

Zinc plated to resist corrosion and improve appearance.



Size: ⅜-16 thread size is ¾-in. across hex flats; ½-13 thread size is ⅞-in. across flats; ⅝-11 thread size is 1 1/16 in. across flats; ¾-10 thread size is 1¼ in. across flats.

Service: Preventing damage to bolt or stud threads which would be exposed with ordinary nut; resist corrosion; make full contact due to contact surface squareness with thread.

Design: Machined from cold finished hexagonal steel stock and case hardened.

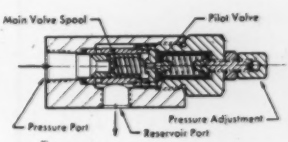
For more data circle MD 15, Page 213

RELIEF VALVES 16

. . . provide precise opening

Fluid Controls Inc., 1284 N. Center St., Mentor, O.

Construction of this valve is such that constant pressure is maintained regardless of flow rate or oil viscosity.



Size: ¼ or ⅜-in. female NPT ports.

Service: For high flow capacity applications where small leakage with valve closed is permissible; may be used with oil or gasoline; adjustable opening pressure ranges of 50 to 1000 psi or 500 to 3000 psi; flow capacity equal to or better than that of matching fittings.

Design; Pilot type relief valve; main valve spool action controlled by flow through small pilot valve; spool positions itself to maintain constant flow through pilot valve; locknut and cover on adjusting screw; valve body of aluminum; moving parts and contacting surfaces of hardened steel.

For more data circle MD 16, Page 213

NEW PARTS

TWO-CYCLE ENGINE 17

. . . light but powerful

Bolens Products Div., Food Machinery and Chemical Corp., Port Washington, Wis.

Developing 2.5 hp, this engine is said to weigh 50 to 60 per cent less than 4-cycle engines developing comparable power.

Designation: Model 375.

Size: 14 11/16 in. long, 11 3/16 in. wide and 14 3/32 in. high; weighs 25 lb.

Service: Develops 2.5 max hp at 4000 rpm; max torque, approximately 3.4 lb-ft at 3200 rpm; easily started; long, trouble-free life; rotation is counterclockwise viewed from power takeoff side.

Design: Single cylinder, two-cycle gasoline engine; block is die cast aluminum with centrifugally cast cylinder liner; aluminum piston has three rings; crankshaft of forged steel has replaceable carburized and ground crank pin; main bearings are three precision ball bearings; connecting rod bearing is replaceable needle bearing; reed and port type intake valves; exhaust valves are port type; lubrication by gasoline-oil mixture; recoil type starter.

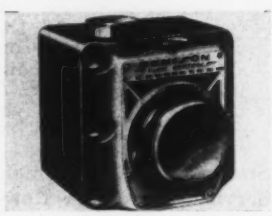
For more data circle MD 17, Page 213

FLOW CONTROL VALVES 18

. . . have wide capacity ranges

Denison Engineering Co., 1160 *Dublin Rd., Columbus* 16, *Ohio*

An adjustable orifice can be varied in both length and width to provide a wide range of flow capacities.



Designation and Size:

Model No.	Port Size (in., IPT)	Width (in.)	Depth (in.)	Height (in.)
VAB023330-A, AC*	¼	3 3/4	3 1/16	4 5/16
VAB033330-A, AC*	⅜, ½	4 7/8	4 1/2	5 1/4
VAB063330-A, AC*	¾	7	5 3/4	6 3/8

* AC has integral check valve

Service: Compensates for pressure variations to deliver constant volume of hydraulic oil; ¼-in., IPT size has min capacity range of 0 to 0.5-gpm, max capacity range of 0 to 4.5 gpm; ⅜ and ½-in. IPT sizes have min capacity range of 0 to 1.5 gpm, max capacity range of 0 to 11 gpm; ¾-in. IPT size has min capacity range of 0 to 5 gpm, max capacity range of 0 to 28 gpm; models with integral check valves permit free flow from outlet to inlet, max operating pressure is 3000 psi.

Design: Multirange flow control valve; knob on front of valve for turning spool to obtain from 0 to 100 per cent of possible flow; calibrated dial indicates percentage; screw with knurled head on top of valve limits range of control; loosening screw permits turning of valve spool in 180 deg increments to desired range; for subplate mounting.

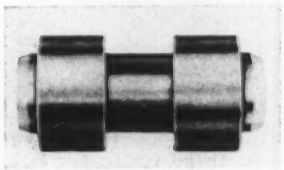
For more data circle MD 18, Page 213

GEAR COUPLING 19

. . . easily disconnected without special tools

Sier-Bath Gear & Pump Co. Inc., 9252 *Hudson Blvd., North Bergen, N. J.*

Hubs may be removed from either shaft without disturbing connected units.



Designation: Spacer type.

Size:

Rough Bore Diam (in.)	Max Bore Diam (in.)	Overall Length (in.)	Outside Diam (in.)	Approx Weight (lb)
⅝	1¼	7⅝	3 5/16	9
¾	1⅝	8⅛	3¾	15
⅞	2⅛	8⅝	4⅜	22
1	2⅝	8⅞	5½	35
1½	3⅛	9⅝	6⅝	53

Service: Easily removed and installed; allow for slight misalignment of coupled shafts; permit end float;

Rough Bore Diam (in.)	Max Speed (rpm)	Max Torque (lb-ft)	Capacity (hp, per 100 rpm)
⅝	25,000	210	4
¾	21,000	630	12
⅞	18,000	1682	32
1	14,000	2522	48
1½	12,200	4204	80

Design: Two flexible hubs for shaft attachment splined to central spacer by collars; four snap rings fasten entire assembly together; tapped holes permit lubrication of splines; neoprene seals retain lubricant; finished bore sizes, keyways and set-screw holes to specifications; larger sizes and other lengths available as specials.

For more data circle MD 19, Page 213

HYDRAULIC PUMPS 20

. . . include extremely large models

Waterbury Tool Div., Vickers Inc., Waterbury 20, *Conn.*

The largest pump in this line delivering 2300 gpm is claimed to be the largest oil hydraulic pump ever built.

Designation and Size: 1¼, 2½, 5, 10, 20, 35, 50, 75, 150, 300; No. 5 is 23 in. long, 16 in. wide, 18 in. high and weighs 615 lb; No. 35 is 46 in. long, 35 in. wide, 39 in. high and weighs 4000 lb; other models are proportionately larger or smaller; 1¼ is smallest; 300 is largest.

Service: Capacities from 28 gpm to 2300 gpm at rated speeds in pressure range of 2000 to 3000 psi; efficiency of all models exceeds 90 per cent at 3000 psi; flow may be reversed;

Size No.	Speed (rpm)	Capacity* (gpm)	Capacity† (gpm)	Input‡ (hp)
5	1200	112	110	104
35	600	410	405	380

* At 0 psi † At 1000 psi ‡ At 3000 psi, max delivery.

Design: Axial-piston, positive-displacement hydraulic pumps; all parts are bronze or steel; highly stressed parts are forgings; units may be furnished with built in auxiliary pumps for control and replenishing and with full-flow relief valves and replenishing valves; motors of same design available from 50 to 400 hp.

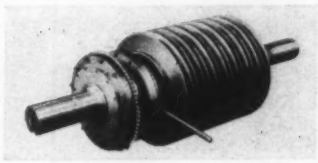
For more data circle MD 20, Page 213

NEW PARTS

MULTIPLE GROOVE PULLEYS 21

. . . provided with built-in pitch control

Allis-Chalmers Mfg. Co., General Machinery Div., Milwaukee 1, Wis.



Integral units are quickly and easily installed or replaced because of standardized shaft lengths.

Designation: Vari-Pitch.

Size: 64½ in. shaft length units supplied with 3 to 10 grooves; 77 in. shaft length units supplied with 3 to 14 grooves; pulley pitch diam, 12 to 15 in., 13 to 16 in., 14 to 17 in.

Service: Suitable as variable-speed drives wherever outboard bearings are employed; pitch can be remotely controlled by pilot motor or manually controlled; rigid construction has fewer parts.

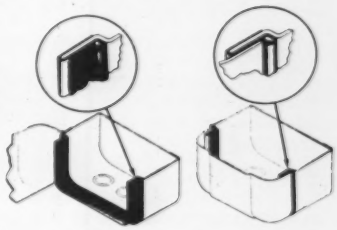
Design: Integral-shaft type variable-pitch, multiple-groove pulley; shaft extensions up to 4¾ in. diam available; floor-stand type manual adjustment mechanism is connected with chain and sprocket; accurate manual adjustment available in direct mounted worm-gear control; has single-row bearings for pulleys up to 10 grooves, double-row bearings for 11 to 14-groove units.

For more data circle MD 21, Page 213

MAGNETIC MOTOR STARTERS 23

. . . with lint-tight enclosures

General Electric Co., Schenectady 5, N. Y.



Enclosure is sealed with an oil-resistant rubber gasket (shown).

Size: NEMA 1-A.

Service: For 1, 2, or 3-phase motors up to 200 hp; rubber gasket prevents entrance of lint, dust, and dirt; compression seal is formed as cover closes against gasket; reduces hazards of fire in textile mills and similar lint and dust areas.

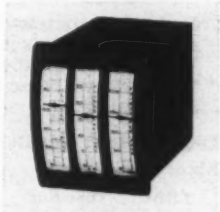
Design: Magnetic combination motor starter; metal enclosure is sealed with U-shaped Buna S rubber gasket; reset button is gasketed; corners and drain holes are sealed with metal filler; conforms to requirements of 1951 revision of National Electric Code.

For more data circle MD 23, Page 213

VERTICAL-SCALE INDICATORS 22

. . . for space-saving panel mounting

Dickson Co., 7420 Woodlawn Ave., Chicago 19, Ill.



Assemblies may include units for pressure, pressure-vacuum, and temperature.

Designation: Mindicator.

Size: Panel-opening—all units, 5⅜ in. high; one-scale unit, 1½ in. wide, two scale unit, 2⅞ in. wide; three-scale unit (shown), 4¼ in. wide; four-scale unit, 5⅝ in. wide.

Service: Used as receivers operating on transmitted pressures of 3 to 15 psig using individually calibrated measuring elements; many different scale readings can be supplied as required; available in direct-reading thermometers in any scale range from as low as −200 F to as high as 1000 F; available in direct-reading pressure gages in many different scale arrangements from a low of 0 to 10 psig to a high of 0 to 1000 psig; indicator housings are complete units permanently installed from rear of equipment or panel board; all units have 4-in. scales.

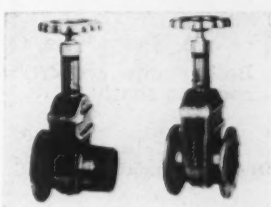
Design: Receivers use metallic bellows measuring elements; thermometers equipped with spiral bourdon tubes and flexible stainless braid-armored capillary connecting tubes for any required length to 150 ft; pressure gages use metallic bellows measuring elements in all ranges below 60 psig, on higher ranges spiral bourdon tubes are used.

For more data circle MD 22, Page 213

GATE VALVE 24

. . . features straight-through flow

Allegheny Valve Co., 346 Pennsylvania Ave. West, Warren, Pa.



Compact design requires less clearance space because stem rises only one-half normal measurement.

Designation: Hose gate, G-1003 and G-1004; flanged gate, G-1013 and G-1014.

Size:

No.	ID (in.)	Flange OD (in.)	Length (in.)	Open Height (in.)	Weight (lb)
G-1003	$3\frac{9}{16}$	$5\frac{5}{8}$	$5\frac{7}{16}$	$15\frac{7}{16}$	10.52
G-1004	$4\frac{9}{16}$	$6\frac{5}{8}$	$5\frac{13}{16}$	$19\frac{13}{16}$	20.00
G-1013	$3\frac{9}{16}$	$5\frac{5}{8}$	$4\frac{1}{2}$	$15\frac{9}{16}$	11.44
G-1014	$4\frac{9}{16}$	$6\frac{5}{8}$	$5\frac{1}{4}$	$20\frac{1}{16}$	18.93

Service: For handling any liquid normally used in other steel or bronze valves; withstands pressures of 600 psi in both open and closed positions; right and left hand threads reduce number of revolutions to open or close by 50%.

Design: Hose-gate valve with 3-in. or 4-in. American Std. pipe threads and flanged-gate valve; seats are stainless steel; bodies are fabricated of welded 12-gage steel stampings, steel tubing, and machined steel bar; stems are ⅝-in. brass; gates are full-floating, two-piece bronze; stuffing boxes have three packing rings, brass gland and cadmium-plated nut; handwheels are cast aluminum alloy.

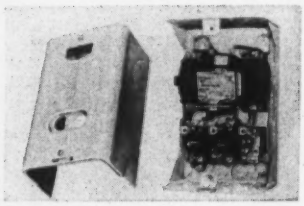
For more data circle MD 24, Page 213

NEW PARTS

MAGNETIC MOTOR STARTERS 25

. . . have wrap-around enclosure cover

Cutler-Hammer Inc., 315 *N. 12th St., Milwaukee* 1, *Wis.*



Starters are constructed of five simple units providing easy installation and maintenance.

Size: NEMA O (shown), 1, and 1½.

Service: For across-the-line type, nonreversing single-phase motors; available for across-the-line type, reversing and nonreversing squirrel-cage motors, and reversing single-phase and polyphase motors in NEMA sizes 0 and 1; removal of wrap-around cover fully exposes front and sides of unit for 180 deg accessibility; adjustable overload relay permits 4 ratings from same heater coil by changing its position; overload protection, within 3% of full load motor rating; contacts, armature and magnet coil can be removed without tools.

Design: Unit consists of five self-contained parts—two contact blocks, magnet coil, armature, and overload relay mounted steel panel which carries magnet frame; vertical contacts made of silver alloy; all terminals angled to face front; cover and base are finished in gray enamel baked on bonderized metal.

For more data circle MD 25, Page 213

PNEUMATIC REVERSING RELAY 27

. . . accurately inverts signal air pressures

Kendall Controls Corp., 144 *Moody St., Waltham* 54, *Mass.*

Reverses input air pressure in large volumes, using force-balance system.

Designation: Model 25.

Size: ¼-in. pipe-thread inlet, outlet and signal ports; 6¾ in. high, 2⅞ in. OD.

Service: Primarily for operating double diaphragm pneumatic control valves; will pass 35 cfm of air with 90 psi supply; reversal is accomplished by utilizing a 2 to 1 diaphragm permitting 3-15 psi instrument signals to change to 15-3 psi relay output.

Design: Force balance system uses controlled-area diaphragms, spring apposed, made of deep convolution nylon inserted Neoprene; die-cast black-anodized body and bonnet; heat treated, polished stainless steel inner valves and seat rings.

For more data circle MD 27, Page 213

DOUBLE HYDRAULIC PUMPS 26

. . . encased in single housing

Vickers Inc. Div., Sperry Corp., 1400 *Oakman Blvd., Detroit* 32, *Mich.*

Both pumps are driven by a common shaft.

Designation and Size:

Series	Length (in.)	OD (in.)	Inlet (in.)	Outlet No. 1 (in.)	Outlet No. 2 (in.)
V-2200	$10\frac{33}{64}$	$5\frac{5}{8}$	$1\frac{1}{4}$	½	½
V-3200	$12\frac{3}{4}$	$5\frac{5}{8}$	2	1	½

Service: Providing two independent hydraulic power sources from a single unit; 10 sizes of series V-2200 pumps available with combinations of 2, 5, 8 or 11 gpm delivery; 16 sizes of series V-3200 pumps available with combinations of 2, 5, 8 or 11 gpm at ½-in. outlet and 12, 15, 18 or 24 gpm at 1-in. outlet; uses oil with viscosity ranging between 150 SSU (light) and 225 SSU (medium) at 100 F for ambient temperatures above 65 F; intermittent operating pressure, 1500 psi max; minimum starting speed, 600 rpm; available for clockwise or counterclockwise shaft rotation.

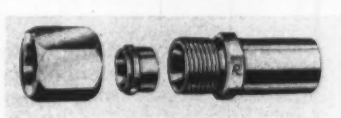
Design: Vane type, constant delivery, double hydraulic pumps in single housing; choice of splined, threaded, or straight keyed shafts and face, flange, or foot mountings; 8 locations of outlets with reference to the inlet are available; inlets and outlets have American Std. pipe threads.

For more data circle MD 26, Page 213

TUBE END REDUCERS 28

. . . for heavy wall tubing

Parker Appliance Co., 17325 *Euclid Ave., Cleveland* 12, *O.*



Reducers increase range of tube sizes that flareless tube fittings will accommodate.

Designation: Ferulok TRBU.

Size:

TRBU Part No.	Tube End Reduction (in., diam)	Overall Length (in.)	TRBU Part No.	Tube End Reduction (in., diam)	Overall Length (in.)
6-4	⅜ to ¼	$1\frac{19}{64}$	12-4	¾ to ¼	$2\frac{19}{64}$
8-4	½ to ¼	$2\frac{9}{64}$	12-6	¾ to ⅜	$2\frac{11}{32}$
8-6	½ to ⅜	$2\frac{9}{16}$	12-8	¾ to ½	2½
10-4	⅝ to ¼	$2\frac{11}{64}$	12-10	¾ to ⅝	$2\frac{13}{32}$
10-6	⅝ to ⅜	$2\frac{7}{32}$	16-8	1 to ½	$2\frac{13}{32}$
10-8	⅝ to ½	2⅝	16-10	1 to ⅝	$2\frac{9}{16}$
			16-12	1 to ¾	$2\frac{11}{32}$

Service: Converting any flareless tube fitting into a combination size unit permitting connection of many sizes of smaller tubing; inserts into tube connection end of regular fitting and is attached with nut and ferrule of regular fitting, other end of reducer is coupled to smaller size tubing with nut and ferrule of reducer; useful where tubing is subjected to high pressure or severe vibration conditions.

Design: Body, nut, and ferrule construction; available in steel, stainless steel, brass, and aluminum.

For more data circle MD 28, Page 213

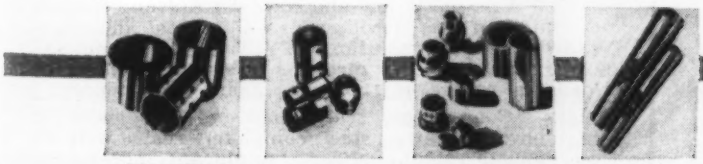
Design your product to use STANDARD STOCK SIZE BEARINGS *to reduce costs*

TOLERANCES:
All inside Diameters plus or minus .001".
TOLERANCES:
All Lengths plus or minus .005".
COMPLETELY MACHINED ID, OD, and ENDS
TOLERANCES:
Outside Diameter up to 3" plus .002" to .003".
Outside Diameter above 3" plus .003" to .005".

PERHAPS only a slight change in product design is necessary to use stock size Johnson GP Cast Bronze Sleeve Bearings. If so, you can cut costs on this item. There are inside diameters available from ¼ inch to 4½ inches, with a selection of wall thicknesses and lengths—over 900 individual sizes. Even if you require slight alterations, slots or oil grooves, the cost still will be much less than for specially made bearings. Many leading manufacturers have adopted stock size Johnson GP Bearings and saved time and money. They are available from your local Johnson Distributor's stock. The Johnson Bearing Catalog lists all stock items . . . write for your copy today.

JOHNSON BRONZE COMPANY
525 South Mill Street, New Castle, Pa.

JOHNSON GP *general purpose* **BEARINGS**



GRAPHITED CAST BRONZE | ELECTRIC MOTOR | LEDALOYL Self-Lubricating | UNIVERSAL BRONZE BARS

JOHNSON JB BEARINGS *Sleeve Type*

OVER 900 sizes in stock at your local distributor's

NEW PARTS

RETAINING RINGS 29

. . . for small diameter shafts

Industrial Retaining Ring Co., 8 *W. Sidney Ave., Mount Vernon, N. Y.*

Smallest size previously obtainable was for ⅛-in. diameter shafts; this smaller size is for $\frac{3}{32}$-in. diam shafts.

Designation: 1000-9.

Size: 0.187-in. OD; for $\frac{3}{32}$-in. diam shafts with groove 0.017-in. wide and 0.010-in. deep.

Service: Act as shoulders on circular shafts; easily snapped into position; support heavy thrust loads and withstand vibration without loosening; can be used to replace other types of fasteners; can be reused.

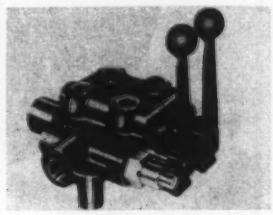
Design: C-shaped rings of carbon spring steel; standard rings are oil dipped, special finishes available on request; supplied stacked on a rod with special tool for installation.

For more data circle MD 29, Page 213

HYDRAULIC CONTROL VALVES 31

. . . easily operated at high pressures

Gre-Sen Mfg. Co., 628 *Colfax Ave North, Minneapolis* 11, *Minn.*



Internal presure balancing prevents valve spools from locking in any position.

Designation: VP series.

Size: 7¾ in wide, $7\frac{9}{16}$ in. high and 8⅞ in. long; weighs 23 lb; ¾-in. IPT inlet and outlet ports; ½-in. IPT control ports.

Service: Controlling hydraulic fluid flow at max pressure rating of 1250 psi; capacity is 24 gpm; relief valve adjustable from 250 to 1250 psi.

Design: Two 4-way, two 3-way or one 3-way and one 4-way valve in combination; valves are fully balanced plunger type; spools are hardened and chrome plated; control handle may be mounted in two positions; hardened relief-valve seat.

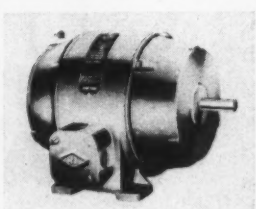
Applications: Controlling double-acting or single-acting hydraulic cylinders.

For more data circle MD 31, Page 213

MULTISPEED MOTORS 30

. . . available with 2, 3 or 4-speed output

Reuland Electric Co., 3001 *W. Mission Rd., Alhambra, Calif.*



Constant torque, variable torque or constant horsepower models are available.

Size: NEMA frame sizes 203 to 326.

Service: Deliver 1/6 to 20 max hp at highest of multiple speeds; maximum speed for any horsepower rating is 3600 rpm; minimum speed is 450 rpm; other speeds are in ratios of 2 to 1 or 1½ to 1; available in constant torque, variable torque, or constant horsepower types; for 208, 220, 440 or 550 v 3-phase ac operation; require no lubrication.

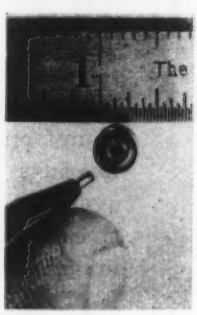
Design: Squirrel-cage motors; reconnection of winding or windings results in speed variation; 2-speed motors have one or two windings; 3 and 4-speed motors have two windings; rotor bars, end rings and fans are pressure-cast of aluminum; stators wound with Formvar wire; life-lubricated, sealed ball bearings; available in drip-proof, splash-proof and totally enclosed models; totally enclosed models in frames 203, 204 and 224 are nonventilated, those in frames 225 through 326 are fan-cooled.

For more data circle MD 30, Page 213

MINIATURE BALL BEARING 32

. . . is lubricated and sealed

Landis and Gyr Inc., 45 *W.* 45*th St., New York* 19, *N.Y.*



Smallest Conrad type ball bearing that has ever been successfully sealed.

Designation: RMB Filmoseal type RF-155.

Size: 0.0591-in. bore, 0.19169-in. OD.

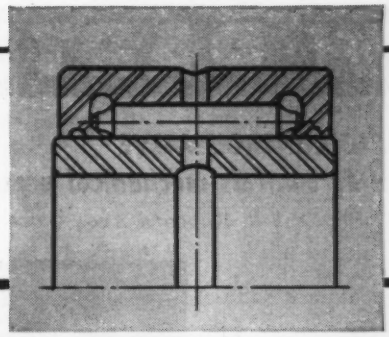
Service: Friction is low and constant for long periods of time and over a wide range of speeds; automatically adjusts to variations in pressure and temperature; unaffected by dirt and moisture; will carry loads in excess of those the shaft can support.

Design: Conrad-type sealed ball bearing; made of high chrome-bearing steel; completely sealed with no mechanical rubbing and no significant increase in friction; also available in larger sizes.

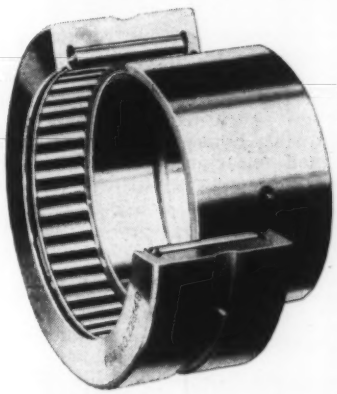
Applications: Precision instruments, computers and small mechanisms.

For more data circle MD 32, Page 213

A bearing design of simplified construction reduces internal wear

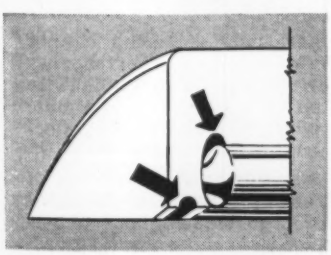


The performance efficiency and life expectancy of anti-friction bearings depends to a great extent on the ability of the bearing designers to hold internal wear to a minimum. They have found that wear can be materially lessened by reducing the number of bearing parts subjected to wear. In the case of MULTIROL SE Series roller bearings all parts have been eliminated except the anti-friction essentials of load carrying rollers and contacting races. Loose or welded in retaining rings and cages ordinarily found in roller bearings of this type have been discarded in the exclusive MULTIROL design.



Here rollers are retained by rolled over lips on end shoulders that are solid extended sections of the outer race. Cages are not required and other delicate parts that may wear, warp or break loose in mounting or in service are not needed. Numerous other advantages accrue from this MULTIROL bearing construction in addition to reduced internal wear and longer bearing life.

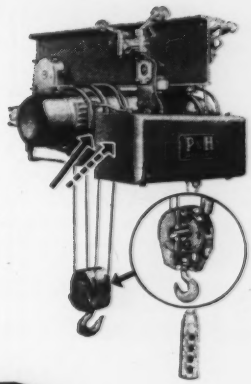
Lubrication Advantages

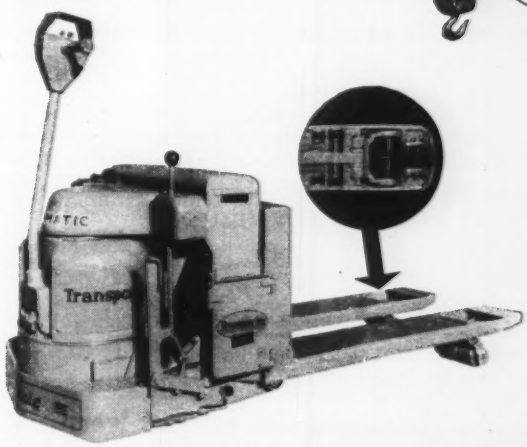


Important among these is the extra protection against destructive foreign particles provided in SE series bearings by a lubricant retaining groove, built into the inside diameter surface of the roller retaining end shoulder. The ring of lubricant held in this groove acts against the inner ring O. D., increasing the sealing effect of the precision tolerances between these shoulders and the inner race. Notice, too, the groove above the roller ends. Acting as a lubricant reservoir, this groove provides MULTIROL SE series bearings with an extra margin of protection against neglected or delayed lubrication.

Typical Performance

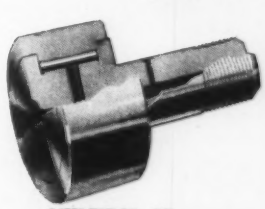
Harnishfeger P&H Hevi-Lift electric hoists carry up to 15,000 pound loads on MULTIROL SE series bearings. Their extra capacity and precision with ruggedness help reduce necessary radial bearing space in the upper and twin bottom sheaves. Two additional SE bearings add smooth efficient and dependable performance in the hoist transmissions.



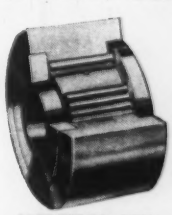


The Automatic Transportation Company's Transporter uses eight Multirol SE Series bearings in the four rear wheels to carry 6000 pound capacity loads easily and freely. Wheels are mounted dual on each fork and two bearings with a center spacer support each wheel. These small but rugged bearings accommodate a large shaft with a comparatively small O. D. and materially reduce starting and rolling friction for finger-tip maneuverability of this heavy duty material handler.

Other McGILL® Bearings



MULTIROL CF



MULTIROL CYR

GUIDEROL CT

A new 140-page Bearing Reference Guide complete with 30 pages of vital engineering data has just been released by the McGill Manufacturing Company. It has the full story on the advantages of Multirol SE Bearings as well as information on the Multirol CF and CYR and Guiderol Bearings. Send now for your copy of McGill Catalog No. 52.

McGILL® — Precision Bearings

McGILL MANUFACTURING COMPANY, INC.
200 N. Lafayette Street, Valparaiso, Indiana

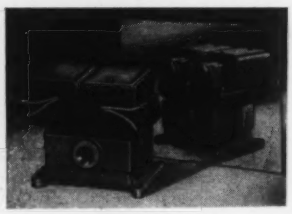
NEW PARTS

PNEUMATIC CONTROL VALVE 33

. . . safely controls mechanical presses

Hannifin Corp., 1101 *S. Kilbourn Ave., Chicago* 24, *Ill.*

Press repeats are eliminated by combining two 3-way valves for control of air-operated clutch and brake mechanisms.



Designation: BB-5.

Size: 6¾ in. long, 6 7/16 in. high and 5 7/16 in. deep; ¾ in. IPT inlet and outlet ports; 1 in. IPT exhaust ports.

Service: Solenoid coils rated 115 v ac, 60 cps, 2.15 amp inrush, 0.50-amp holding; operating pressures of 35 to 125 psi; capable of more than 600 operating cycles per minute; will pass 150 cfm free air per minute with 3.5 psi pressure drop and 80 psi inlet pressure.

Design: Dual, 3-way pneumatic valves with common inlet and outlet ports; incorporates two solenoids for pilot valve actuation; pilot valves in turn actuate main valves; pilot valves and main valves are pneumatically interlocked so that if either pilot valve or either main valve fails or jams in the operating position, the other side still exhausts to stop operation; one solenoid, one pilot valve and one main valve can fail and press action will still be stopped; solenoids for other voltages available.

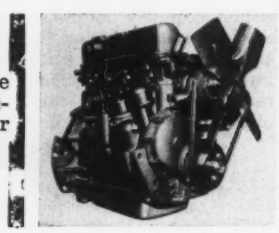
For more data circle MD 33, Page 213

INDUSTRIAL ENGINE 34

. . . . low-friction design reduces wear

Ford Motor Co., 3000 *Schaefer Rd., Dearborn, Mich.*

Bore nearly equal to stroke is said to result in less friction, less wear and better fuel economy.



Designation: 134.

Size: 20.62 in. wide; 44.97 in. from front of radiator core to rear of air cleaner bracket; height from oil pan drain plug to top of radiator cap is 33.82 in.; weighs 489 lb; SAE No. 5 flywheel housing; 3.4375 in. bore and 3.6 in. stroke.

Service: Develops 45 bhp at 2400 rpm; maximum torque is 110 lb-ft at 1200 to 1750 rpm; does not require high-octane gasoline.

Design: Four-cylinder, four-cycle gasoline engine; overhead valves of high chrome nickel alloy; cylinders cast enbloc of high-grade iron; centrifugal cast cylinder sleeves; replaceable, thin shell, copper-lead bearings; full-length water jackets; full-flow oil filter with renewable filtering element.

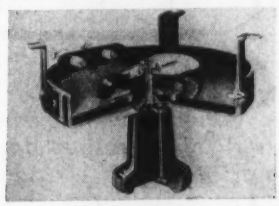
For more data circle MD 34, Page 213

POWER RHEOSTATS 35

. . . require low operating torque

Ward Leonard Electric Co., Mount Vernon, N. Y.

Obtainable with a wide range of resistance values and current tapers.



Designation: Bulletin 60A, types S and M.

Size: 6, 8 or 13 in. diam.

Service: Maximum summation wattage is 330 w for 6 in. diam, 450 for 8 in. diam and 1000 w for 13 in. diam; rated 600 v dc max; available in a wide range of resistances, current values and tapers; resist vibration and mechanical shock; 41 to 161 control steps.

Design: Resistance element of special alloy wire with low temperature coefficient of resistance; stationary contacts of brass; movable contact of graphite is removable for inspection or replacement; contact arm keyed directly to drive shaft; self-lubricating drive shaft bushings; type M has more stationary contacts than type S for finer degree of control if required; large operating handwheel of molded insulating material; housed in pressed-steel case with black japanned exterior finish and special interior finish of vitreous-enamel insulating material.

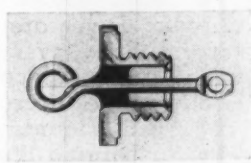
For more data circle MD 35, Page 213

FEED-THROUGH TERMINALS 36

. . . provide positive mechanical connection

Fusite Corp., 6000 *Fernview Ave., Cincinnati* 13, *O.*

Threaded-bushing units afford a safeguard when vibration is a problem.



Designation and Size:

Model	Bushing Height (in.)	Hex. Flange (in.)	Bushing Threads
104 TB-SW	15/32	7/16	8-32
105 TB-LFP	7/32	5/8	¼-28
109 TB-HT	¼	½	5/8-24

Service: Used primarily where soft soldering cannot be used; terminals can be screwed into corresponding size threaded holes or inserted through hole in light gage material and pulled tight with jam nut; dielectric strength, 1000 v rms for model 109; electrode is insulated from bushing with glass.

Design: Electrical feed-through terminals consisting of a cold-rolled steel electrode fused to a threaded bushing with Fusite No. 47 borosilicate glass; terminals are available with eyelet-type electrode (shown), straight-rod electrode, hollow-tube electrode, and various other electrode treatments.

For more data circle MD 36, Page 213

Facts about *HELI-COIL* inserts you should know

What they are

*Heli-Coil** screw thread inserts are precision formed coils of stainless steel or phosphor bronze wire. Wound into tapped holes, they form permanent, non-corrosive, strip-proof threads of astonishing strength. Available for National Coarse, National Fine and Unified threads, pipe threads and spark plug threads. They are made in all standard sizes and lengths for assemblies requiring Class 3, 3B, 2 or 2B fits.

What they are for

AS ORIGINAL COMPONENTS: *Heli-Coil* inserts are used to provide stronger, lighter fastenings, corrosion-proof, wear-proof threads in all assemblies.

FOR PRODUCTION SALVAGE: When conventional tapped holes are damaged in production, restore them on the line with *Heli-Coil* inserts. Get better-than-original strength with no increase in screw size and no tell-tale signs of rework.

FOR SPEEDY REPAIRS: When tapped threads wear, strip or corrode in service, renew them in minutes on location in shop or field with *Heli-Coil* inserts. No welding—no plugging—no secondary machining—no oversize screws.

How they work

Holes are drilled and tapped as you do for ordinary threads—then *Heli-Coil* inserts are wound into tapped holes by hand or power tools. Install in a few seconds, assure thread protection forever. Can be used in any metal wood or plastic.

No other method is so simple, effective and practical.

What they do for you

Heli-Coil inserts *save money* because they strengthen threads and make *fewer* smaller fastenings do the same holding job. They make *lighter* bosses and flanges practical and they *save weight* in two ways: (1) by permitting use of cap screws, instead of bolts and nuts; (2) by allowing use of smaller, shorter, fewer cap screws. *Heli-Coil* inserts *protect* your product from thread wear, galling and stripping for life in every kind of metal, in plastics or wood. They preserve customer good-will by preventing product failure, due to thread fault. *Heli-Coil* inserts improve the end product, cut rejects, salvage threading errors.

Best time to put *Heli-Coil* inserts benefits to your use is right at the designing board, as many leading manufacturers are doing. But to convince you of their many advantages ask for a working demonstration right on your production line. Write today! Complete information and engineering data is available in the *Heli-Coil* catalog. Use Coupon!

*Reg. U.S. Pat. Off.

Approved for All Military and Industrial Uses

Advertisement

How to save headaches *in fastenings*

1-2-3

1

Lend an ear to the many successes with tapped threads where stripping, wear, cross-threading and corrosion used to occur.

2

Open your eyes to the surest way to end thread problems forever—*Heli-Coil** Screw Thread Inserts. This armored protection is simple to add—costs little—never fails.

3

Tell us about your products and we will show you how to add lasting protection against thread problems right on your production lines.

HELI-COIL **inserts** are precision formed stainless steel or phosphor bronze wire coils that add strength to screw threads in any material—especially in light metals and plastics. The result—an improved product—usually at *reduced* production cost.

Write now for FREE samples and complete technical data.

HELI-COIL CORPORATION

125 SHELTER ROCK LANE, DANBURY, CONN.

☐ Send Free samples and Handbook No. 652, a complete design manual.

☐ Send Free samples and put my name on list to receive "Heli-Call," case history periodcal.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

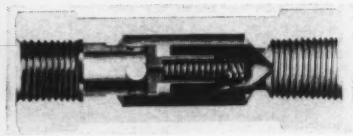
CITY_____ ZONE____ STATE_____ 7101

NEW PARTS

CHECK VALVE 37

. . . has low pressure drop

Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.



Valve is provided with nylon poppet which assures leakproof trouble-free service.

Designation and Size:

Model No.	Pipe Size (NPT in.)	OD (in.)	Length (in.)
341-3	⅜	⅞	3⅛
341-4	½	1⅛	3½
341-6	¾	1⅜	5⅛
341-8	1	2	6

Service: For use in oil, air or water with working pressures to 3000 psi; has minimum pressure loss at rated flow for a given line size.

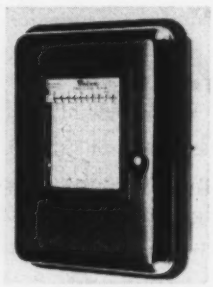
Design: Check valve consists of one-piece aluminum housing, check, spring, check stop, nylon poppet and retaining ring; one-piece construction—no welds or brazes to crack or fail.

For more data circle MD 37, Page 213

SPEED RECORDER 38

. . . has wide choice of speed ranges

Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.



An overlapping dot curve is plotted by pointer pressuring a typewriter ribbon against chart once every two seconds.

Designation: Series 81M.

Size: 9⅛ in. wide, 12⅝ in. high, 5⅛ in. deep; weight, 14 lb.

Service: For recording speed on strip-chart paper in any units desired; chart speeds of 1 or 3 inches per hour are available; 18 speed-range markings from 0-50 to 0-100,000; accuracy within 2% of full scale; can provide uninterrupted service for as long as 30 days on a single strip-chart roll; charts are 4 in. wide, 65 ft long, and have 50 or 60 minor divisions depending upon speed range selected; two terminals are provided for connection of recorder to tachometer head and two for connection to any 115 v, 60 cycle outlet.

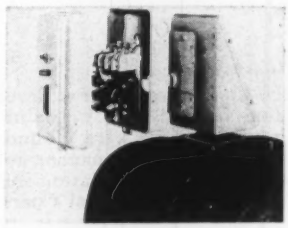
Design: General Electric type CF-5 strip chart recorder modified for use with Metron tachometer indicators and heads; recorder uses d'Arsonval movement.

For more data circle MD 38, Page 213

MOTOR STARTERS 39

. . . for direct mounting on motors

Furnas Electric Co., 1045 McKee St., Batavia, Ill.



These controls save labor, space, and conduit between starter and motor.

Designation: Motor-Mount.

Service and Size: For direct mounting on motors set at any angle; nonreversing units available in sizes up to 10 hp at 220, 440, or 550 v polyphase; reversing units available in sizes up to 7½ hp at 220 v and 10 hp at 440 or 550 v polyphase.

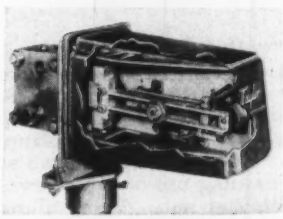
Design: Starter and contactors in metal enclosure, plus starter mounts which consist of (1) two sizes of steel plates—one for nonreversing and the other for reversing starters—used where the motor outlet-pad face is in the vertical position or up to 45 deg from the vertical and (2) an adapter box used in combination with either plate for applications where outlet-pad face is in the horizontal position or up to 45 deg therefrom.

For more data circle MD 39, Page 213

PRESSURE TRANSMITTER 40

. . . rugged, accurate, and easily installed

Taylor Instruments Co., 95 Ames St., Rochester, N. Y.



Instrument senses a differential pressure and converts it to a proportional output air pressure.

Designation: Transaire.

Size: 6 in. wide, 14½ in. long, 7⅜ in. high; weight, 23 lb.

Service: Measuring flow of liquid, steam, or gas; measures liquid level or specific gravity; converts differential pressure into equivalent 3 to 15 psi output; ranges, 0-20 in. water to 0-200 in. water and 0-80 in. water to 0-800 in. water; working pressure, 1500 psi max; diaphragm operating temperature, 300 F max; case ambient temperature, 180 F max; accuracy, within 1% of full range; both high and low pressure sides equipped with two ½-in. pressure taps.

Design: Differential pressure meter consisting of two basic units (1) measuring unit—forged or stainless steel housing enclosing a Teflon-coated, glass-fabric diaphragm (2) transmitting unit enclosed by a gasketed aluminum cover; has hydraulic capillary-type damping system.

For more data circle MD 40, Page 213

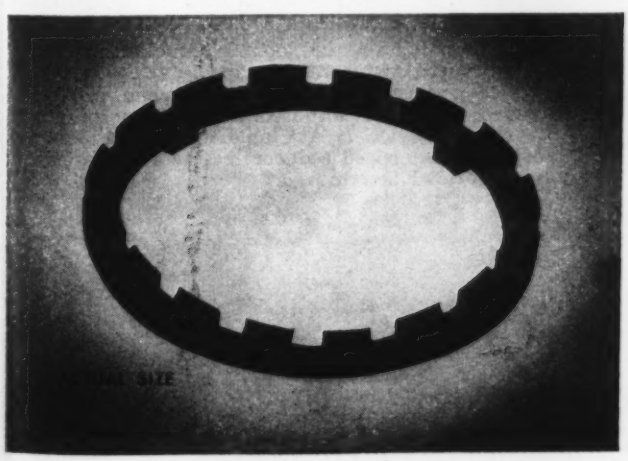
Precision casting news

by Arwood Engineers

Another part designed for economy — the red brass Ball Bearing Retainer illustrated below.

The retainer is cast in two halves each containing its half of the bearing pocket and rivet holes. Since this part is a bearing, Arwood's engineers have maintained a true roundness and smooth flat surfaces to permit a close fit and proper operation of the assembly.

TIP TO DESIGN ENGINEERS— The part illustrated below needs no further machining after casting. The pockets, the pitch diameters of those pockets, and the rivet holes are all held to very close tolerances. In addition the exact placement of rivet holes must be obtained in order to insure the perfect alignment of rivets when assembling the unit. We have illustrated a part cast in a copper base alloy, but we also cast parts in magnesium, aluminum, carbon, stainless, and various other steels. Details are in our booklet, "A Critical Survey of Investment Castings."

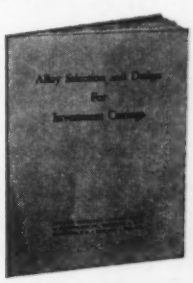


from Arwood

ART STOLKEY

Art Stolkey, Arwood's representative in Michigan, was one of the first investment casting foundry representatives in the area and has witnessed and helped the amazing growth of interest in the process in his territory. Today most of the engineers in Michigan's industries realize the importance of the investment casting process and are evaluating its use.

Like all Arwood representatives, Mr. Stolkey's experience enables him to help engineers and industrial buyers decide which difficult jobs can be produced quickly, accurately, and more economically by the Arwood Precision Casting method.



For more complete information write for our booklet, "Alloy Selection and Design for Investment Castings."

☆ ☆ ☆

An important new book—"Investment Casting for Engineers"—has just been published by Reinhold Publishing Co., New York. It is highly recommended reading for all design engineers.

ARWOOD

PRECISION CASTING CORP.

78 WASHINGTON STREET • BROOKLYN 1, N. Y.

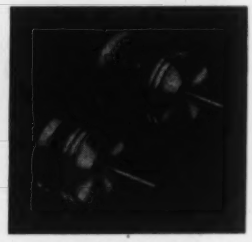
Plants: Brooklyn, N. Y., Groton, Conn., Tilton, N. H.

NEW PARTS

PRECISION POTENTIOMETER 41

. . . small but precise

Control Systems Components, Station Plaza Bldg., Hartsdale, N. Y.



Claimed to be the smallest precision potentiometer produced whose output can be sinusoidal, logarithmic, or exponential without loss of resolution.

Designation: Micromax type 105.

Size: Single unit is 1 3/32 in. diam, 11/16-in. long and weighs 1 oz; shaft diam is 0.125-in.; add ¼-in. for each additional section.

Service: Resistance ranges of 500 to 100,000 ohm; will dissipate 2 w; electrical function angle is 350 or 360 degrees; mechanical rotation, continuous; linear resistance values are correct within 0.5 per cent; accuracy of non-linear resistances is +5.0 per cent; single unit starting torque is 0.075 oz-in.; for temperatures from −55 to 80 C; guaranteed life of 1 million operating cycles.

Design: Carbon film resistance element; double ball bearings; internal trimming to meet customers loading requirements; for servo type mounting; available as specials with higher accuracies; taps to a maximum of 7 may be added.

For more data circle MD 41, Page 213

MINIATURE THERMOSTAT 42

. . . rectangular or cylindrical models

Fenwal Inc., Ashland, Mass.

Precise temperature control and small size and weight make these thermostats useful for small precision mechanisms.

Size: Rectangular model is ¾ by ⅜ by 1½-in.; cylindrical model is ¾-in. diam and 1½-in. thick.

Service: Contacts open at any desired temperature from 0 to 200 F; contacts rated 2.5 amp at 115 v ac or 2 amp at 28 v dc; sensitivity is less than 1F; will withstand 5*g* vibration at frequencies of 50 to 500 cps; contact opening temperature easily adjusted.

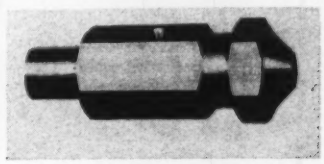
Design: Differential expansion type thermostat; outer stainless steel shell is high expansion member; inner strut assembly of special alloy is low-expansion member; covers of molded phenolic; adjuster screw permits setting of desired opening temperature.

For more data circle MD 42, Page 213

AUTOMATIC DRAIN VALVE 43

. . . eliminates manual bleeding of air tanks

Westinghouse Air Brake Co., Industrial Products Div., Wilmerding, Pa.



Applicable to any air reservoir, the valve automatically bleeds off moisture every time the compressor starts, stops or unloads.

Designation: C-1.

Size: 5 1/16 in. long, 1⅝ in. hex size; weighs 10 oz; ⅛-in. NPT female ports.

Service: Automatically bleeds air reservoirs; water is atomized and evaporates as it leaves valve, no drain lines are required; no attention or maintenance required; resists corrosion.

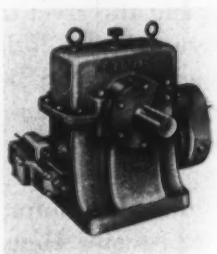
Design: Air pressure in reservoir holds valve piston in retracted position when line to compressor unloader pipe is vented; when compressor starts, pressure in unloader line moves piston to extended position; when compressor stops or unloads, piston returns to retracted position; as piston moves in either direction exhaust groove uncovers exhaust ports to expel moisture; all metal valve parts are aluminum; packings are of rubber composition; kits containing valve, tubing and all necessary fittings are available.

For more data circle MD 43, Page 213

SPEED REDUCERS 44

. . . have automatic overload protection

Philadelphia Gear Works Inc., G St. below Erie Ave., Philadelphia 34, Pa.



Automatic overload device is adjustable, permitting the user to vary or select required release torque.

Size: To 260 hp.

Service: Ratios from 3⅝ to 1 to 6300 to 1; output torque ratings to more than 370,000 lb-in.

Design: Single-reduction and double-reduction helical worm-gear speed reducers; overload device is preloaded spring acting against worm; when preload is exceeded, switch is actuated to break motor circuit; overload device is available on any standard Philadelphia Gear speed reducer; resets automatically when overload is removed.

For more data circle MD 44, Page 213

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Automotive Accessories
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Washing Machines
Standard & Special Machine Tools
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*Cartridge Seal . . . pressure balanced . . . requiring only 25% more space than lip-type seals.

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Gits Lubricating Devices,
The Standard For Industry For Over 40 Years

NEW PARTS

PRECISION POTENTIOMETER 41

. . . small but precise

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Design: Carbon film resistance element; double ball bearings; internal trimming to meet customers loading requirements; for servo type mounting; available as specials with higher accuracies; taps to a maximum of 7 may be added.

For more data circle MD 41, Page 213

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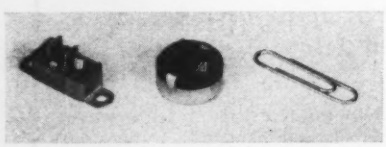

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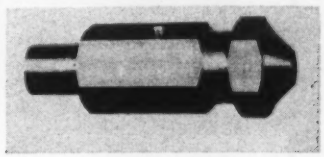

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For more data circle MD 43, Page 213

SPEED REDUCERS 44

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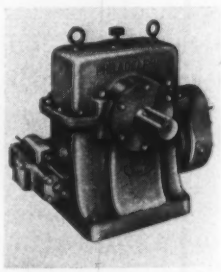
Philadelphia Gear Works Inc., G St. below Erie Ave., Philadelphia 34, Pa.



Automatic overload device is adjustable, permitting the user to vary or select required release torque.

Size: To 260 hp.

Service: Ratios from 3⅝ to 1 to 6300 to 1; output torque ratings to more than 370,000 lb-in.

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For more data circle MD 44, Page 213

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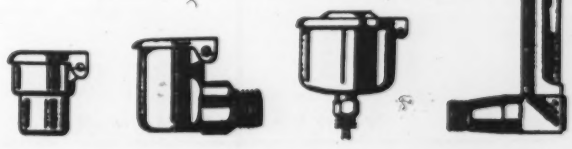
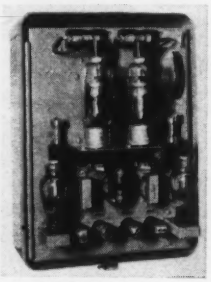


NEW PARTS

ADJUSTABLE-SPEED DRIVE 45

. . . controls dc shunt-wound motors

General Electric Co., Schenectady 5, N. Y.



Packaged electronic drive operates on ac power but gives dc performance.

Designation: Thy-mo-trol.

Size: Electronic panel (shown), 15⅛ in. wide, 20⅛ in. high, $12\frac{7}{16}$ in. deep; control stations, 3 x $2\frac{37}{32}$ x $8\frac{11}{32}$ in. and 3 x $2\frac{11}{32}$ x $10\frac{7}{32}$ in.; anode transformers, $6\frac{3}{32}$ x 6¾ x $12\frac{13}{32}$ to $7\frac{1}{16}$ x 8⅝ x $17\frac{11}{32}$; motors, ¾, 1, 1½, 2, and 3 hp.

Service: Provides stepless speed control by turning knob on control station; speeds can be preset by setting speed-control knob before starting; drive has dynamic braking and overload and undervoltage protection; speed regulation, ±3%; speed ranges, 5 to 1—1750 to 350 rpm and 20 to 1—1750 to 88 rpm; operates in ambient temperatures from 50 F to 104 F; standard drives operate on either 220 or 440 volts, 50 or 60 cycles, single phase.

Design: Standard air-cooled type M anode transformer supplies thyratron voltage; complete setup includes electronic control panel, controlled current rectifier, control station, on-off pushbuttons, speed potentiometer and selected dc shunt-wound motor; motor speed adjusted by changing dc armature voltage, field is supplied with a constant dc voltage.

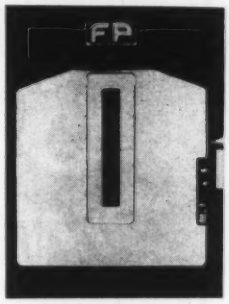
Applications: Machine tools, conveyors, printing presses, and variable—volume or proportioning pump installations.

For more data circle MD 45, Page 213

MOVING-SCALE INDICATOR 47

. . . positioned with servomechanism

Fischer & Porter Co., 10 Jacksonville Rd., Hatboro, Pa.



Device uses a long strip scale moving behind a fixed horizontal hairline.

Size: 14 in. wide, 18 in. high, 12 in. deep.

Service: Providing highly accurate readings from primary sensing instruments such as flow meters; since readings are made at same eye level, and scale and hairline are close together, parallax is virtually eliminated; 72-in. scale provides reading accuracy better than one part in 2000; scale can be calibrated in any units desired; can be located up to 2000 feet from primary instrument with no loss in accuracy; up to four scales may be installed in a single case, all scales being geared to a common receiver; has 115 v regulated power supply; frequency fluctuation of 5 cps have no discernible effect on system; temperature changes of ±50 F from design value (70 F) alter indicator less than ±0.1% of full scale.

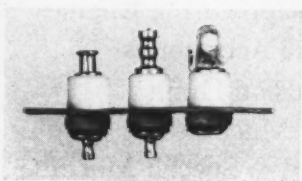
Design: 35-mm film scale behind a fixed hairline is synchronized to movement of an armature by servo action; soft-iron armature is supported with glass mountings to eliminate expansion effects; reading portion of film scale is held to constant length between a pair of spring-loaded drive sprockets.

For more data circle MD 47, Page 213

MINIATURE HERMETIC TERMINALS 46

. . . have Teflon and silicone-rubber seals

Lundley Associates, 694 Main St., Waltham 54, Mass.



Terminals are mounted in drilled or punched holes with a minimum center to center distance of $\frac{15}{61}$-inch.

Designation and Size:

No.	Outside Diam. (in.)	Overall Length (in.)	Mounting Hole Diam. (in.)
199E	7/32	9/16	0.157
199TH	7/32	35/64	0.157
199D-TH	7/32	41/64	0.157

Service: For hermetically-sealing electric assemblies; operating voltage rating, 500 v rms; current rating, 8 amp; No. 199E—assembled by clinching eyelet in press, No. 199TH and 199D-TH assembled by telescoping electrode into inverted eyelet; seal is effected by soldering tinned eyelet and stud together.

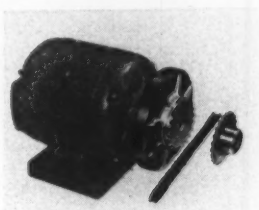
Design: No. 199E—hollow eyeletted electrode for minimum internal clearance and ease of wiring, No. 199TH—solid electrode type with single turret head, No. 199D-TH—solid electrode type with double turret head; Teflon and silicone rubber seals—for oil-filled units, inner insulator is neoprene instead of silicone; service available of installing terminals in customer's covers.

For more data circle MD 46, Page 213

FLUID COUPLING 48

. . . mounts directly on standard motor

L. & S. Industries, Box 577, Norwalk, Calif.



This fluid coupling is no larger in diameter than a standard motor and is not much thicker than a sheave or pulley.

Designation and Size:

Model No.	Diam (in.)	Thickness (in.)	Motor Shaft Diam (in.)
6.5	6½	2¼	⅝ or ¾
8.5	8½	2¼	¾ or 1
9.5	9½	2¼	¾ or 1

Service: Hp capacities from ¼ to 4 at 1750 rpm; available with four different torque vs. slip characteristics for varying applications; easily installed or removed.

Design: Torque transmitted from driving to driven member by viscous silicone fluid; torque transmitted is limited by construction of coupling during high slip periods; supplied with chain type flexible coupling for ⅝, ¾ or 1 in. shaft or V-belt pulley.

For more data circle MD 48, Page 213

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NEW PARTS

HIGH-TEMPERATURE OIL 49

. . . for use at 500 F or above

E. F. Houghton & Co., 303 *W. Lehigh Ave., Philadelphia* 33, *Pa.*

Molybdenum disulphide, synthetic-base and low-carbon content petroleum oil make this oil suitable for high temperature lubrication.

Designation: 303.

Form: Fluid.

Size: 1, 5, or 15 gal pails, 30 or 55 gal drums.

Service: Lubrication at temperatures of 500 F or higher; easily fogged in automatic lubricators; does not deposit carbon.

Properties: Colloidal molybdenum disulphide, high temperature synthetic fluid and a light, volatile carrying oil; carrying oil is dissipated at high temperatures to leave film of synthetic lubricant and molybdenum disulphide; lubricating film has high load-carrying ability; will not separate in storage.

For more data circle MD 49, Page 213

O-RINGS 51

. . . in forty-nine new sizes

Precision Rubber Products Corp., 3110 *Oakridge Dr., Dayton* 7, *O.*

Sizes listed here are new additions to the line of O-rings manufactured by this company.

Designation and Size: Part Nos. 914-1 through 914-16, from 9/16 to 1½ in. nominal OD with 1/16-in. nominal cross-section in OD increments of 1/16.; part Nos. 914-17 through 919-49, from 1 to 3 in. nominal OD in 1/16-in. OD increments with 3/32-in. nominal cross sections.

Service: Static or dynamic sealing; resist attack by hydraulic fluids, lubricating oils, mild acids and alkalis, alcohols and coolants, gasoline, fuel, diesel oils and water; for temperatures from −40 to 260 F.

Design: O-rings molded of standard rubber and synthetic-rubber compounds to meet above service conditions; also available in many other formulations to meet a variety of military specifications and many other types of service conditions.

For more data circle MD 51, Page 213

RELIEF VALVE 50

. . . maintains constant pressure

James-Pond-Clark, 2181 *East Foothill Blvd., Pasadena* 8, *Calif.*

Will hold pressure slightly under cracking pressure for indefinite periods and permit no back leakage.

Designation: P-249, P-262.

Size: ¾-in. hex; 9/16-18 or ¼-in. IPT threads; length is approximately ½-in.

Service: Used as vent or breather valves; open at 0.25 to 20 psi, tolerance of ±10 per cent; operate at temperatures of −80 to 400 F; maximum flow rates of 0.5 to 1.0 cfm, depending on cracking pressure; resist corrosion; for use with air, nitrogen, helium, carbon dioxide, engine oil or hydraulic fluid.

Design: Plunger type valve; seat seals against O-ring; outlet end of P-249 in hex end, of P-262 threaded end; made from aluminum, brass or stainless steel.

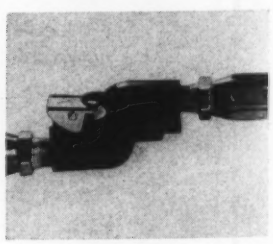
For more data circle MD 50, Page 213

HOSE CONNECTORS 52

. . . seal automatically when pushed together

Aeroquip Corp., Jackson, Mich.

Hoses equipped with these connectors are easily connected and disconnected with a simple push-pull action, similar to that used in inserting or removing a plug from an electrical outlet.



Designation: 6500-4, 6500-6.

Size: Overall length of joined connectors is 2 1/16 in.; width is 7/8-in.; height is 2 13/64 in.; 6500-4 has 1/8-27 NPTF threads; 6500-6 has ¼-18 NPTF threads; approximate weight, 0.15-lb.

Service: Working pressure of 800 psi; fluid flow shutoff when uncoupled; will not leak; cannot be accidentally pulled apart.

Design: Die-cast aluminum bodies mated by dovetail joint; latch mechanism initiates opening action and locks automatically when connection is made; threads are Dryseal; O-ring seals used in shutoff valves are operated by disconnecting.

For more data circle MD 52, Page 213

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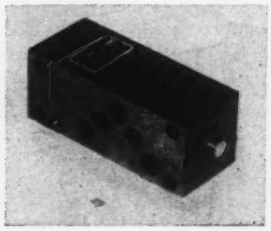
NEW PARTS

HYDRAULIC CONTROL VALVE 53

. . . has linear output flow

Hydraulic Controls Co., 87 Terrace St., Roxbury 20, Mass.



Nitralloy moving parts assure long service life and smoothness of operation.

Designation: CO.

Size: 1¾ by 1¾ by 4½ in. with valve spool fully extended; ⅜-in. diam ports.

Service: Delivers 3 gpm at 3000 psi with 50 psi pressure drop and ±$\frac{1}{16}$-in. valve stroke; working pressure, 3000 psi; small actuating force required.

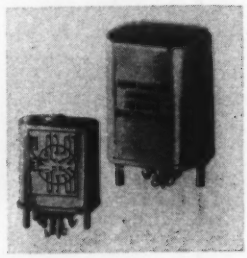
Design: Plunger type valve for cam or linkage actuation; spring-loaded plunger will follow cam movement; lands of plunger all machined to match internal port dimensions, resulting in linear flow with a negligible dead zone; parts subject to wear are hardened tool steel or Nitralloy; valve body of steel or aluminum; ports may be threaded for pipe or tubing connections, if desired.

For more data circle MD 53, Page 213

HERMETICALLY SEALED RELAY 55

. . . smaller and lighter than previous model

R-B-M Div., Essex Wire Corp., Logansport, Ind.



Overall size and weight of this relay are one-half of that of previous relays meeting specification AN 3304-1.

Designation: Series 22300.

Size: $1\frac{33}{64}$ in. high, $1\frac{31}{64}$ in wide and $\frac{15}{16}$ in. thick; weighs approximately 2½ oz.

Service: Rated 3 amp at 28 v dc; coil resistance is 5000 ohm max; unaffected by dirt, dust or moisture.

Design: Relay with 6 form A or 4 form C contacts; palladium crossbar contacts; AN 3304 type enclosure; meets MIL-R-6106 specification; solder hook terminals; side or top mounting is optional.

For more data circle MD 55, Page 213

MOLY SULFIDE LUBRICANT 54

. . . provides tenaciously bonded coating

Alpha Corp., 170 Hamilton Ave., Greenwich, Conn.

Useful wherever a heavy, long-lasting dry lubricating film is needed.

Designation: Molykote M-88.

Form: Liquid.

Service: Lubricating where dust or abrasive materials tend to collect on surfaces and parts; use where flying oil and grease is objectionable; applied to clean, metallic or nonmetallic surfaces by spraying, brushing, or dipping; maximum uniformity and minimum thickness of coating is obtained if surfaces are heated to 200 F; heated surfaces insure more tenacious coating; heating speeds solvent evaporation which minimizes running.

Properties: Dispersion of near-colloidal particles of molybdenum disulfide powder in highly volatile solvent; organic binder in composition insures layer buildup which provides heavier, longer-lasting film than possible with powdered lubricants; solvent evaporation leaves a coating ranging from 0.003 to 0.007-in. thickness.

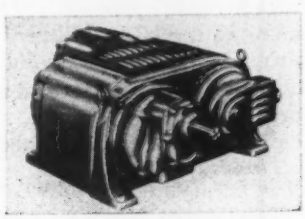
Applications: Food, paper or textile machines; loading and dumping equipment; tractors and farm implements.

For more data circle MD 54, Page 213

VARIABLE-SPEED DRIVE 56

. . . provides 10 to 1 speed change

U. S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.



Motor, variable speed transmission and gearing are included in integral construction.

Designation: 64 VE Varidrive.

Size: 30 hp motor.

Service: Providing a compact variable-speed drive for applications requiring horizontal assemblies; motor controls may be located above or at side of motor.

Design: Drive unit uses splined grooved pulleys turning double-cog V-belts, with tension control for permanent belt adjustment; has asbestos-protected motor; available with either single or double reduction gearing; remote controls available with either mechanical extensions or electric pushbutton stations.

For more data circle MD 56, Page 213

What

makes Adlake Mercury Relays more dependable than conventional types?

"Mighty Midget" ADLAKE Relay Contact normally open or closed.

DEPENDABILITY is the sum of many things... and ADLAKE'S dependability is built on engineering skill, exhaustive testing, and quality construction features like these:

Positive leak-proof sealing—assured by the use of properly selected metals and glass components with properly matched thermal expansion characteristics.

Arc-resisting ceramics—ceramics with great temperature-resistance are used to reduce any destructive effect caused by the arc.

Liquid, mercury-to-mercury contacts—completely eliminates failures caused by low contact pressure, contact burning, pitting and sticking—and the inherent high surface tension of mercury imparts an ideal snap action to the contacts.

Yes—as thousands of enthusiastic users in every branch of industry know—ADLAKE means dependability every way! Write for your free copy of the ADLAKE Relay Catalog today... The Adams & Westlake Company, 1173 N. Michigan, Elkhart, Indiana. In Canada write: Powerlite Devices, Limited, of Toronto.

Every ADLAKE Relay is tested—
***and guaranteed*—to meet specifications!**

THE Adams & Westlake COMPANY

Established 1857 • ELKHART, INDIANA • New York • Chicago

Manufacturers of ADLAKE Hermetically Sealed Mercury Relays

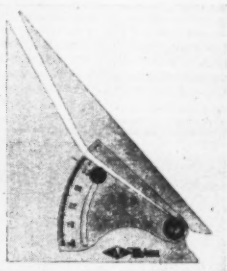
Adlake 96th year of serving the transportation and building industries

EQUIPMENT

ADJUSTABLE PROTRACTOR TRIANGLE 57

. . . provides rapid angle measurements

Alvin Co., Windsor, Conn.



Adjustable feature permits quick setting to precise graduations of one-half degree.

Designation: Tru-Angle.

Size: 6 in., 8 in., and 10 in. lengths.

Service: For measuring and laying off angles; has two rows of graduations—outer row showing angles from 0 to 45 deg, inner row showing angles from 45 to 90 deg from the shorter base; eliminates blind spots; shatterproof and heat-resistant.

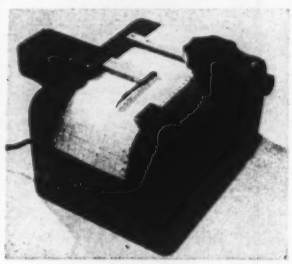
Design: Clear Plexiglass protractor wrapped in plastic cover.

For more data circle MD 57, Page 213

SQUARE ROOT PLANIMETER 59

. . . has four-place readout counter

Librascope Inc., 1607 Flower St., Glendale 1, Calif.



Accuracy of instrument is comparable to stability of the chart paper.

Designation: Model 303634.

Size: 8⅛ in. length, 10 in. width, 4⅛ in. depth; weight, 10 lb.

Service: For flow-rate totalizing of 3-inch miniature, graphic-panel strip-chart recorders manufactured by Brown Instruments, Moore Products, Swarthout Co., and Taylor Instrument Co.; provides for true square-root extraction and integration without approximation over entire range of flow; operation requires no leader on chart paper, totalizing from leading to trailing edge of paper can be accommodated; planimeter chart speeds, one or two ft per second; power requirement—115 v, 50 cycles, 35 w.

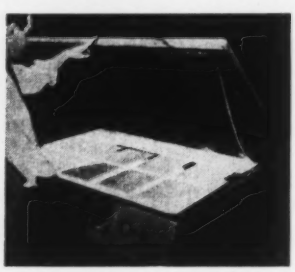
Design: Planimeter; motor driven sprocket; four-place readout counter; also available for linear integration.

For more data circle MD 59, Page 213

VACUUM PRINTER 58

. . . has rubber blanket under lid

Peerless Photo Products Inc., Shoreham, L. I., N. Y.



Rolling action of rubber blanket reduces failure due to loss of registration.

Designation: Magic Hand.

Size: 38 by 50 in., 44 by 74 in., and 50 by 98 in.

Service: Providing fast multiprinting of large or small prints; lightweight lid is opened and closed with one finger; can be loaded with large number of small prints without disturbing the register; as lid is closed forward, rolling action of rubber blanket squeezes out excess air, vacuum pump quickly evacuates the space between blanket and glass, giving firm close contact; printing surface is provided with uniform illumination by fluorescent lamps in reflectors.

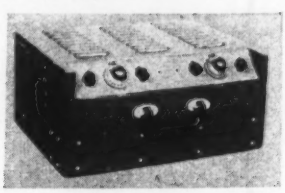
Design: Rubber blanket suspended from light, internally counterbalanced frame; equipped with instant-starting fluorescent lamps.

For more data circle MD 58, Page 213

RECORDER AMPLIFIER 60

. . . lightweight, portable unit

Goodyear Aircraft Corp., Akron 15, O.



Two-channel unit can be used where a large recorder would be impractical.

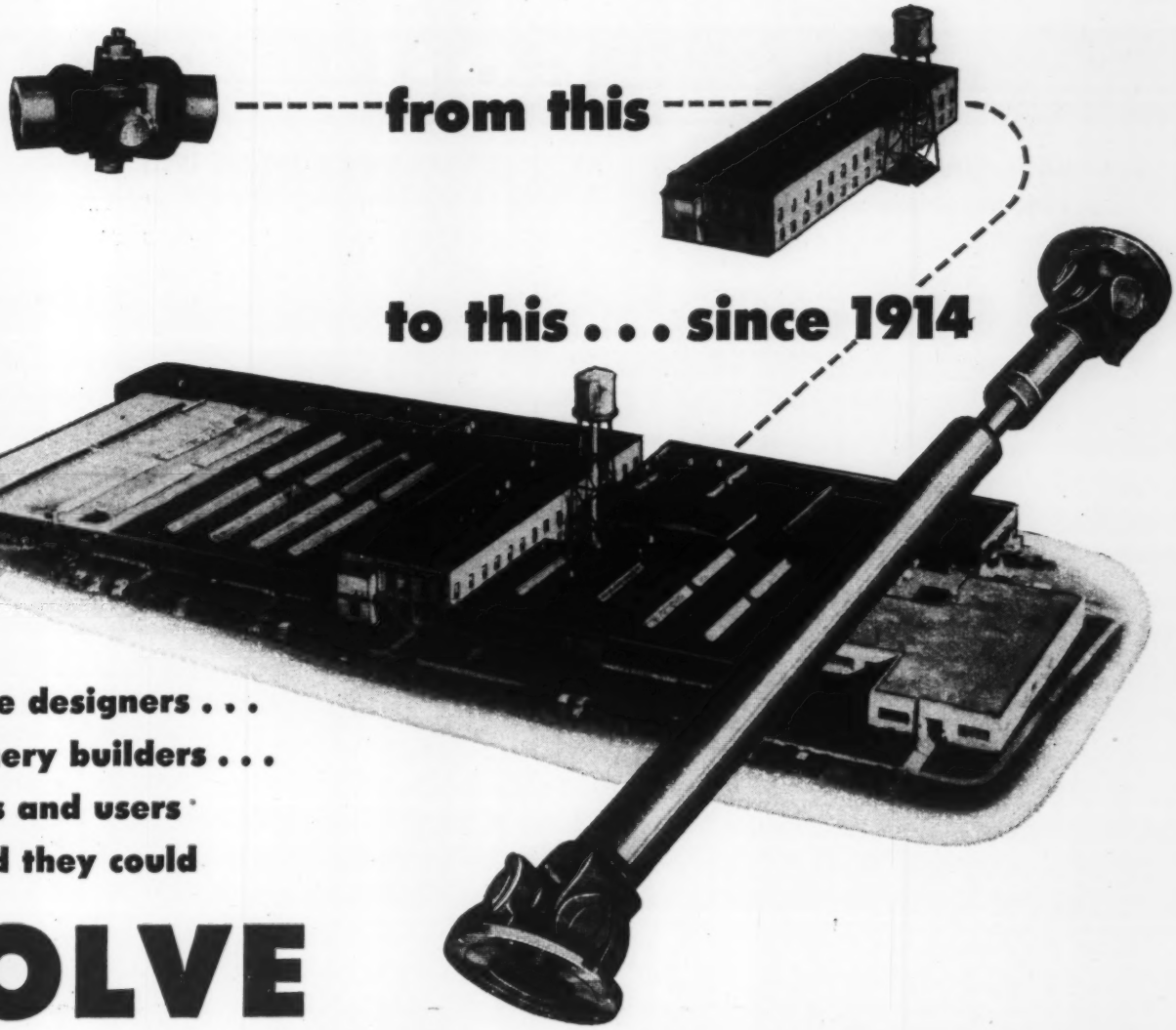
Designation: Model R3.

Size: 17¾ in. wide, 8¾ in. high, 14¼ in. deep; weight, 40 lb.

Service: For use in testing such devices as servomechanisms, in plotting solutions to differential equations set up on associated linear and nonlinear Goodyear GEDA equipment, in recording low-frequency signals emitted by electronic equipment, and in strain-gage measurements; converts voltages into form that can be shown on associated standard direct-writing recording galvanometers that record two channels of information; frequency response, flat within 3% from dc to 100 cycles; input impedance, 2.5 to 10 megohms depending on range; has own power supply and voltage regulator; power requirement—105 to 125 v ac, single phase, 150 w.

Design: Two-channel amplifier; each channel has three controls—decade attenuator, vernier attenuator, and balance potentiometer; each channel has four-pin polarized socket at rear of case.

For more data circle MD 60, Page 213



because designers . . .
machinery builders . . .
dealers and users
learned they could

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BUILT IN A WIDE RANGE OF SIZES AND TYPES

FOR AGRICULTURAL AND CONSTRUCTION MACHINERY

	Maximum Torque Inch Pounds	
K Series K2R Series	Cont. Load	Hand Oper.
K-1-C	350	2,000
K-2-A	350	5,000
L6S Series L6N Series	400	2,000

	Recommended Torque Rating, Inch Pounds	Needle Bearings
L10S Series	650	Opt.
1FR Series	1,080	"
L14S Series	1,230	"
3DR Series	1,800	"
L16S Series	2,200	"
L14N Series	4,500	"
35N Series	10,000	"

FOR TRUCKS AND BUSES

N Series	Recommended Torque Rating, Inch Pounds	Balanced for
45N	14,000	3600
5N	20,000	R.P.M.
50N	20,000	Max.
6N	38,000	"
60N	38,000	"
7N	57,000	"
70N	57,000	"
75N	70,000	"

FOR MARINE AND INDUSTRIAL EQUIPMENT

BW Series	Maximum Torque Inch Pounds Cont. Load	Momentary Load
BW-12	1,020	4,450
BW-1	1,695	7,500
BW-2	3,350	11,720
BW-3	4,450	16,800
BW-4	5,080	22,900
BW-5	8,640	34,200
BW-6	11,620	60,000
BW-7	28,600	150,000
BW-9	89,300	500,000

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UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

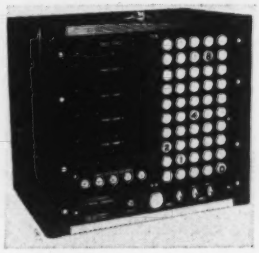
A Division of Standard Steel Spring Co. • Chicago Office: 122 S. Michigan

EQUIPMENT

ELECTRONIC COUNTER 61

. . . requires no warm-up time

Haledy Electronics Co., 57 William St., New York 5, N. Y.



Output information is registered on panel by large illuminated numerals.

Designation: Model GW.

Size: 22 in. wide, 19½ in. high, 15 in. deep; weight, 70 lb.

Service: For high speed counting to any predetermined number; used where exact measures and control of frequency, quantity, length, time, velocity, or revolution are desired; direct panel readouts without any interpolations or additions for any digit; preset number selected by dial switches on panel—when number registers, unit actuates a control relay which may be utilized to perform a given function; reset is manual or automatic; control rate up to 15,000 per min; count capacity, 10 digits; input signal, 30 to 70 v positive pulse with max rise time of 4 milliseconds and with max peak duration of 10 microseconds; power requirement—115 v, 60 cycles, 75 w.

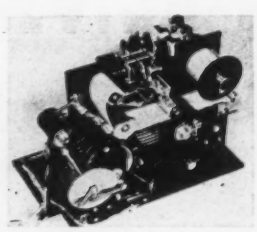
Design: Electronic counter; cold-cathode triode tube circuit.

For more data circle MD 61, Page 213

ANALOG DATA RECORDER 62

. . . provides visual or printed information

Streeter-Amet Co., 4101 Ravenswood Ave., Chicago 13, Ill.



Unit is based on a servo system which automatically adjusts a potentiometer for each change in recorder input voltage.

Designation: Ametron.

Service: Measuring and recording virtually any physical quantity capable of being converted into a corresponding voltage; solves measuring problems dealing with temperature, weight-force, pressure, voltage, light intensity, current, pH concentration, resistance, rpm, stress-strain, angle displacement, and distance; operates through various sensing devices—tachometer generators, thermocouples, photocells, pressure cells, load cells, etc.; can be operated remotely; can be switched to print data from one sensing device to another—automatically or manually; records printed digits on cards, tickets, or tape; time, identification letters, or symbols can be printed opposite quantity recorded; can be equipped with visual dial attached locally or remotely; can be used as computer.

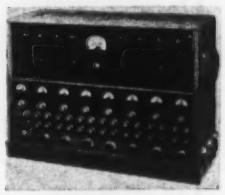
Design: Basic recorder elements—potentiometer balancing bridge, zero balance adjustment, three-stage amplifier, and two-direction balancing motor; balancing motor rotates step cams which position type-wheels; available in desk, wall, or cabinet models.

For more data circle MD 62, Page 213

STRAIN-GAGE CONTROL UNIT 63

. . . drives oscillograph galvanometers

Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.



Features are compactness, high frequency response, and freedom from effects of vibration and shock.

Designation: Type MRC-21.

Size:

Number of Channels	Width (in.)	Height (in.)	Depth (in.)	Weight (lb)
6	16½	11½	8	32
8 (shown)	21½	11½	8	38
12	16½	17	8	45

Service: For use with resistance strain gages and oscillographs for recording static-dynamic strain; for airborne, mobile, or portable applications where shock and vibration may be encountered; calibration accuracy, better than 0.25%; frequency ranges (1) for carrier type amplifier elements, 0 to 1500 cps (2) for linear-type amplifier elements, 2 to 6000 cps; maximum output (1) for carrier-type amplifier elements, ±40 ma in 25-ohm load (2) for linear-type amplifier elements, 240 ma in 3-ohm load or 80 ma in 25-ohm load; power requirement—300 v, 200 ma dc and 6.3 y, 12 amp dc.

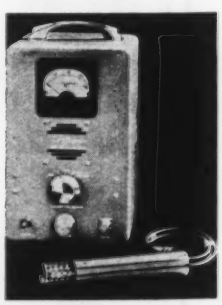
Design: Portable multichannel amplifier; each amplifier element has provision for balancing of its associated strain gage bridge circuit; amplifier elements are removable and interchangeable.

For more data circle MD 63, Page 213

COUNT-RATE METER 64

. . . provides pulse frequency monitoring

Berkeley Scientific Co. Div., Beckman Instruments Inc., 2200 Wright Ave., Richmond, Calif.



Front panel control permits selection of five different count ranges.

Designation: Model 1800.

Size: 6½ in. wide, 10¼ in. high, 6½ in. deep; weight, 8 lb.

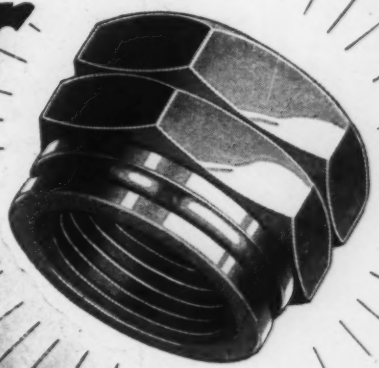
Service: For laboratory count-rate metering with provision for visual and/or aural indication; aural volume can be controlled from zero to maximum level; ranges—300, 1000, 3000, 10,000 and 30,000 counts per minute; accuracy, ±5%; input sensitivity and range calibration adjusting done at rear of instruments; calibration is necessary only on 300, 3000, and 30,000 count-per-minute ranges; power requirement—117 v ac ±10%, 35w.

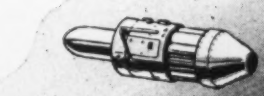
Design: Unit consists of a radio-frequency high-voltage power supply, a Geiger-Mueller input trigger and pulse shaping circuit, a metering circuit which measures average plate current of a one-shot multivibrator, and a thyratron trigger circuit driven loudspeaker; available with or without Victoreen 1B85 aluminum-wall Geiger-Mueller tube, sliding shield probe assembly, and cable.

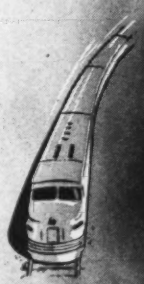
For more data circle MD 64, Page 213

MORE AND MORE ENGINEERS ARE SPECIFYING

Klincher LOCKNUT







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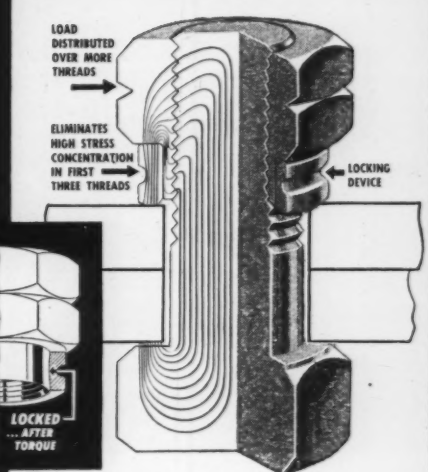
High Temperature
Fastening up to

1600°

. . . particularly where high frequency vibration, tensile strength and re-usability are factors!



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Inquiries invited regarding specialized locknut problems. Write for data and experimental samples, giving size and application.

KLINCHER ADVANTAGES:

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After breakaway, nut spins off freely, ready for reuse, without impairment of locking efficiency.

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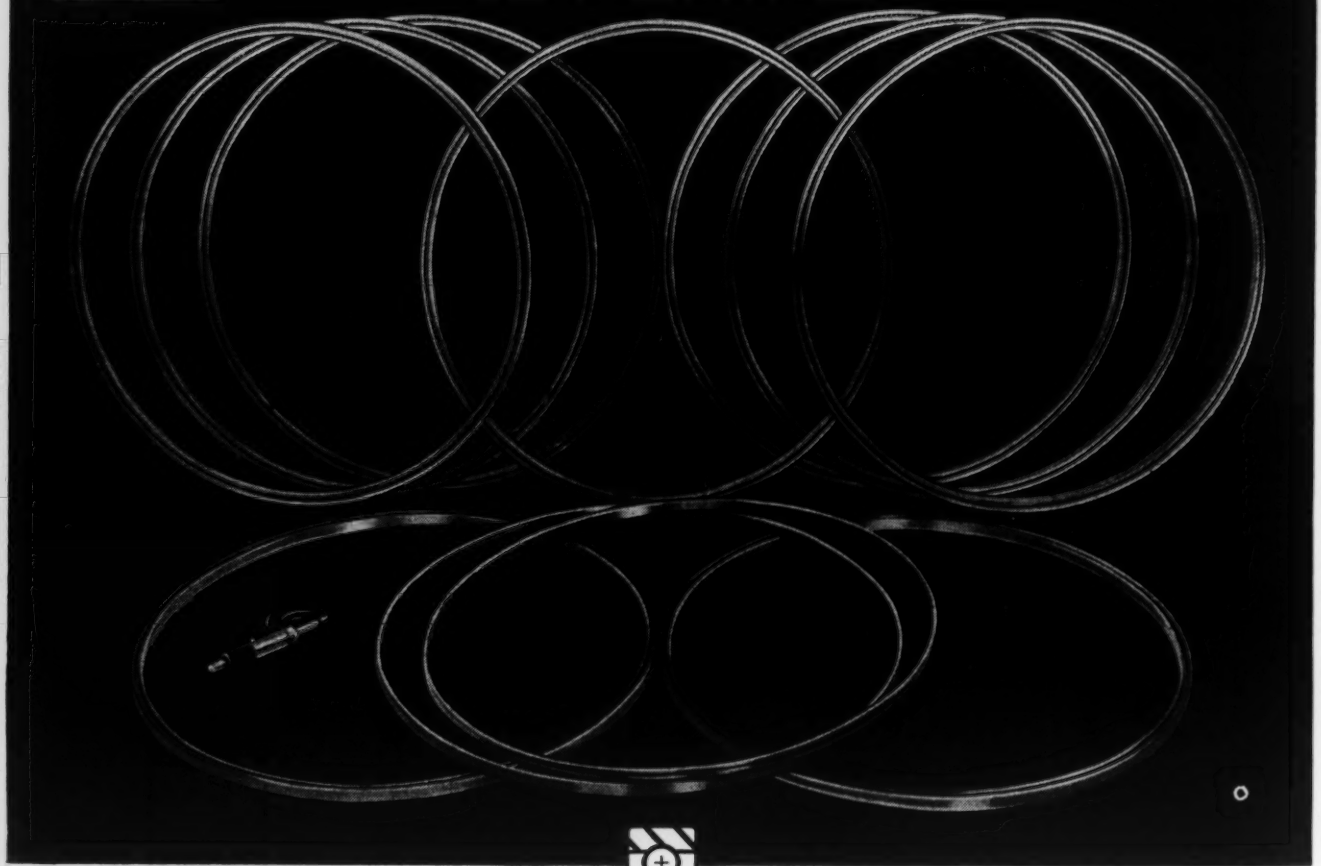
DESIGNED FOR PRECISION RADAR MOUNTS



ACTUAL SECTION: ONLY 3/8" x 3/8"

NET WEIGHT: 2 Pounds

WORLD'S THINNEST BEARINGS

THIN AS A WEDDING RING... WITH THE PRECISION OF FINE WATCH PARTS

We specialize in large, thin-section, light weight precision bearings for Aircraft, Automotive and Industrial Equipment

Proportionately, that's an understatement! A wedding ring as big as 17.625" outside diameter would be about four times as thick as the actual 0.375" section of these thin KAYDON bearings... and even the finest watch parts, enlarged proportionately, probably would not have the precision tolerance to which these bearings are consistently finished. • These are by far the thinnest ball bearings ever made in this large diameter. KAYDON has developed the facilities and special techniques vital to such precision production.

Precision miracles in extremely large bearings of unusually thin section have become routine achievements at KAYDON. In addition to unique thinness that conserves space and weight, other outstanding features have been embodied in many special KAYDON bearings ... for instance: Flame hardened bearing races drilled, tapped and gear-cut by the KAYDON process eliminate costly auxiliary parts, help improve machine design and performance, and make possible more compact, lighter machines of greater capacity.

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THE KAYDON ENGINEERING CORP.

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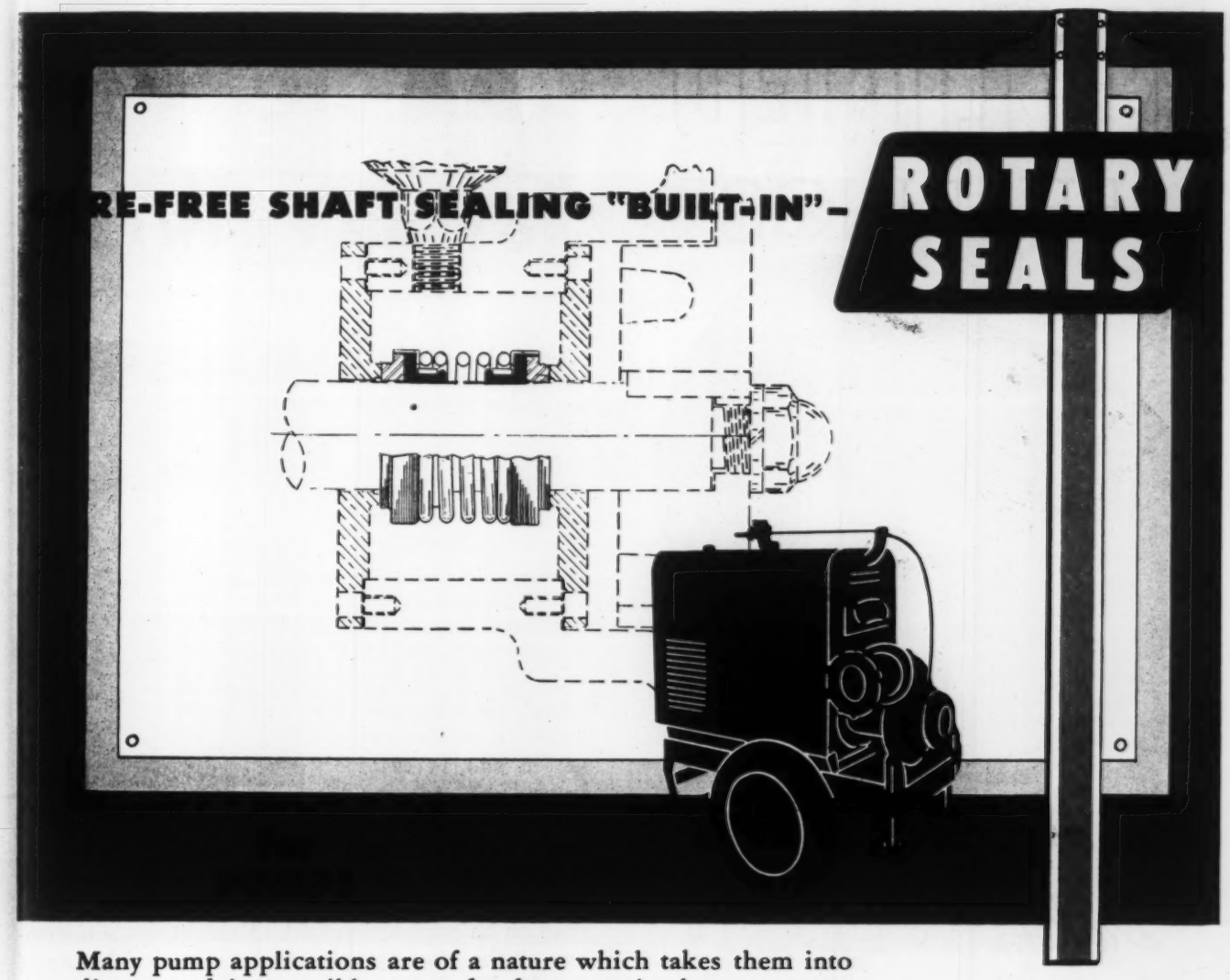
PRECISION BALL AND ROLLER BEARINGS



Many pump applications are of a nature which takes them into distant and inaccessible spots, far from repair shops or parts depots. For example, centrifugal pumps used with many kinds of continuous-operation irrigation systems are often called upon for day and night performance deep in farming country. Breakdowns there can be serious, repairs may be difficult. Under such circumstances, it's no wonder that so many leading pump manufacturers have standardized on ROTARY SEAL for *Shaft Sealing with Certainty.* Their reasoning is logical: why take chances on the troubles frequently encountered with stuffing box arrangements or other outmoded sealing methods, when years of performance by ROTARY SEALS have clearly demonstrated that these problems can be avoided?

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mechanical seals for rotating shafts

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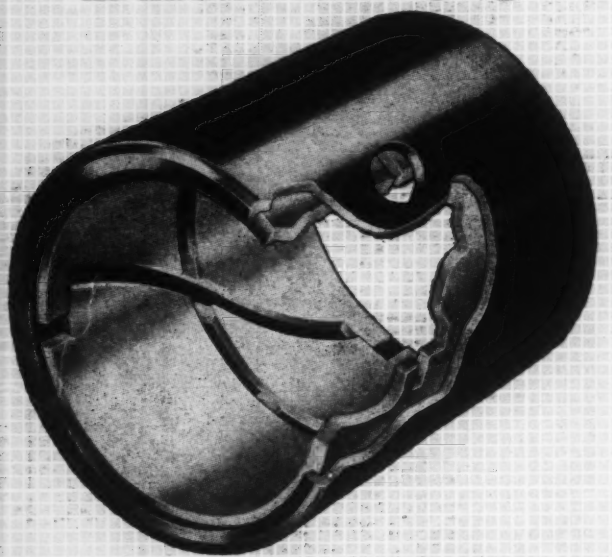

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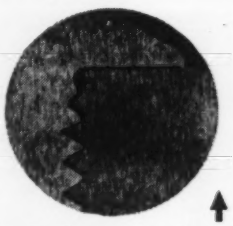
•

Tom R. Smith

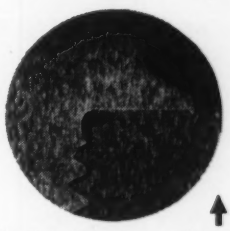
Director of research and development for the Maytag Co., Newton, Iowa, since 1938, **Tom R. Smith** was elected to the newly created office of vice president in charge of research and development. Mr. Smith first began his association with Maytag following his graduation from high school in 1926 and was employed in the machine shops for 15 months before enrolling at the University of Iowa, from which he transferred to Massachusetts Institute of Technology. He received his degree in 1932 and returned to Maytag a year later as a machine operator. In 1934 he transferred to the experimental department as a design engineer. The staff of the department at that time consisted

Stronger!

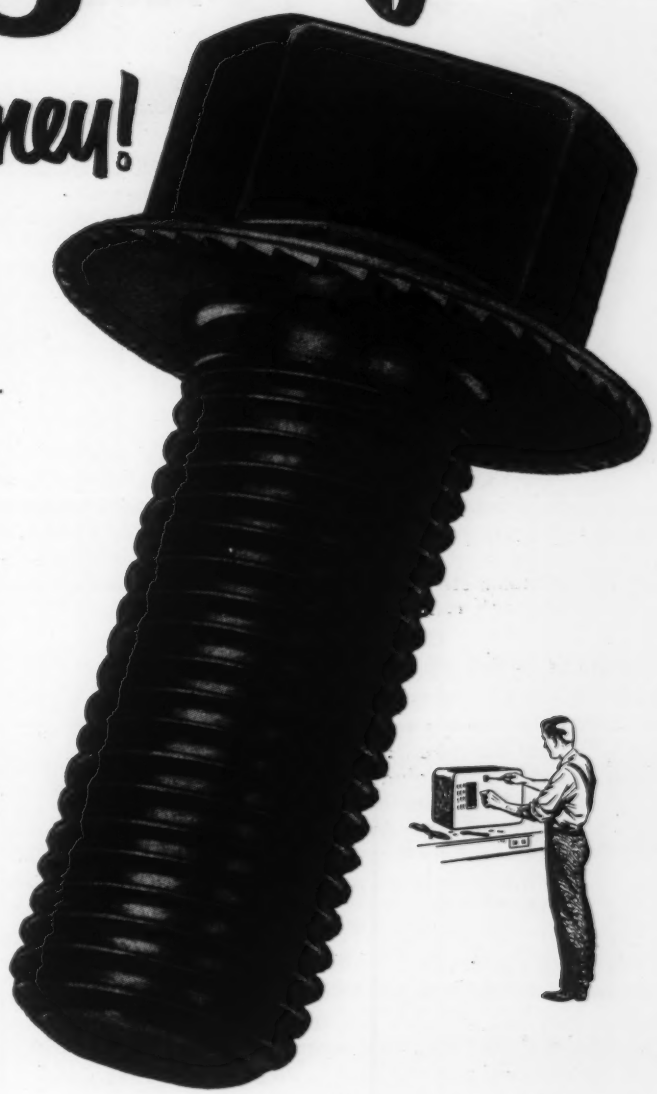
Faster! Saves Money!



Teeth of SPIN-LOCK Screw touch bearing surface before final tightening.



Final tightening embeds teeth in surface, assuring positive locking.



That's the unique RB&W SPIN-LOCK Screw

This patented new screw rings the bell three times:

Stronger... SPIN-LOCK exerts *greater clamping force* because of its heat-treated strength. It *can't loosen* because its exclusive ratchet-like teeth lock into the surface, hold tighter than ordinary fasteners under vibration.

Faster... SPIN-LOCK needs *no washers*. It *drives easily and quickly*, even in hard-to-reach spots. *No special handling* is required—SPIN-LOCK screws can be hopper-fed.

Saves money... SPIN-LOCK's *one-piece construction* means there's just *one part to buy and stock*. Purchasing and inventory-taking move along faster, cost less. Faster assembly cuts costs. Hex, pan, truss, flat heads.

Write to Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y., for free booklet containing complete data and specifications on the SPIN-LOCK Screw.

RB&W—The Complete Quality Line. *Plants at:* Port Chester, N .Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. *Additional sales offices at:* Philadelphia, Pittsburgh, Detroit, Chicago, Dallas, San Francisco. *Sales agents:* Portland, Seattle. Distributors from coast to coast. B.3.2

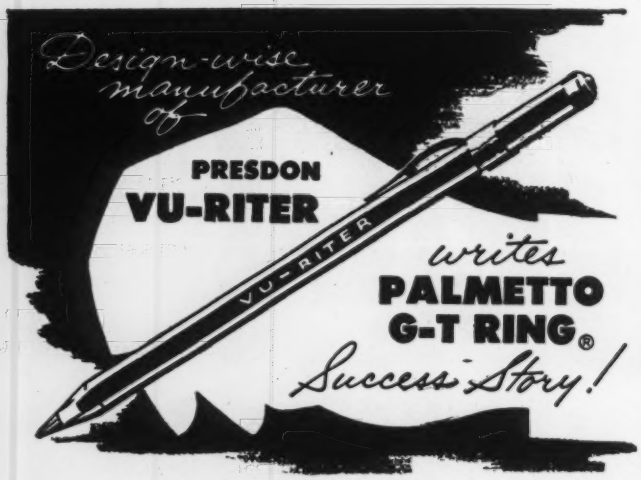
RB&W

Spin-lock

U. S. Pat. No. 2,253,241

The Tighter, Stronger, Surer Fastener!

108 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG



Ferber Corp. of Englewood, N. J. in building its own hydraulic printing presses to imprint its nationally known line of Presdon Vu-Riter pens, had a tricky packing problem. They tackled it—licked it—and presented another example of how Palmetto G-T Rings give better answers to tough packing assignments.

Rod had to be Oil Free...

Ferber's press had a chrome plated ¼" piston rod reciprocating 144 strokes/min.; Working Pressure—550 psi; Hydraulic Medium—"Sunvis" 916; Temperature—approx. 150 F. Oil, if carried on rod, would contaminate stock and interfere with printing . . . *therefore rod must be free of oil.*

PALMETTO G-T Rings the Answer...

Other type packing rings were tried but when results were not satisfactory, glands were modified to accommodate Palmetto G-T Rings. After *6 months without maintenance,* Ferber installed Palmetto G-T Rings in *four more machines with equally good results.* (NOTE: Each of these rods "travel" nearly 9 miles in a working day!)

What's your problem?

Palmetto G-T Rings are recommended for use as seals in hydraulic and pneumatic cylinders and valves, welding machines, hydraulic steering gears, control units, testing equipment and in applications where simplification of design and weight are prime factors. Extrusion of the packing material is eliminated. Where can Palmetto G-T Rings help you?

Write for your complimentary copy of the new Greene, Tweed manual. This helpful 32-page handbook for the design engineer covers Palmetto G-T Packings in detail—as well as other noteworthy Palmetto Molded Packings.

90 YEARS Quality

packing more performance into every application

PALMETTO Packings

GREENE, TWEED & CO. NORTH WALES, PA.

Men of Machines

of six people, two of whom were engineers. All current Maytag products have been developed in the Research and Development Div. under Mr. Smith's direction.

♦

S. L. Crawshaw has been named president of Amgears Inc., Chicago. He will also serve as executive head of the company's Chicago operations. Until this appointment he was assistant to the president of Western Gear Works and before that was chief engineer of the Nuttall Works of Westinghouse Electric Corp. A specialist on gearing, Mr. Crawshaw wrote the Gearing Section of the Twelfth Edition of *Kent's Mechanical Engineers' Handbook,* Design and Production Volume. He is currently serving as president of the American Gear Manufacturers Association, as announced in the July 1952 issue of MACHINE DESIGN, Page 184.

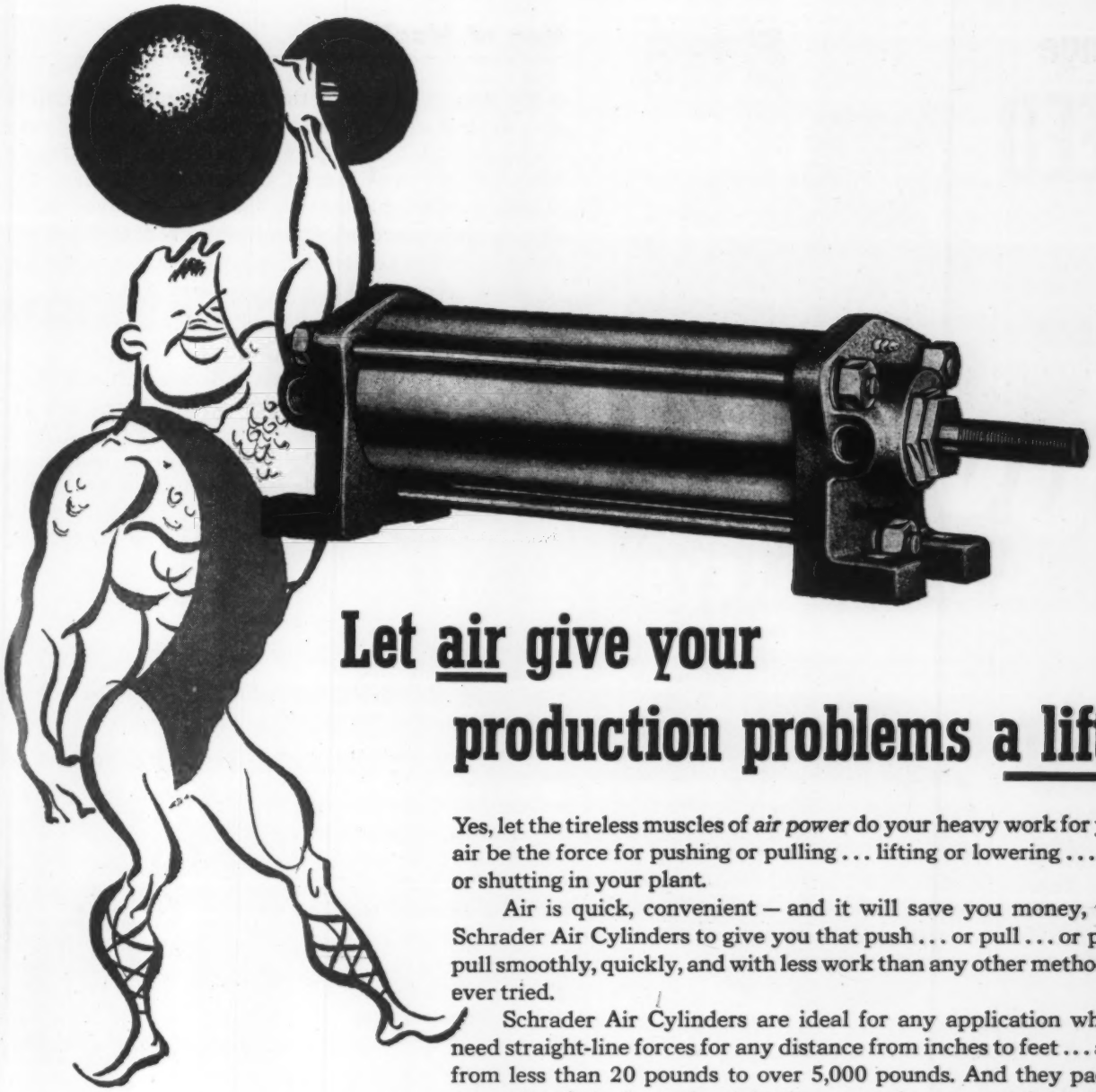
♦

John N. MacKendrick

John N. MacKendrick has been appointed president of Clark Bros. Co., Olean, N. Y., succeeding **C. Paul Clark,** who has been named chairman. A graduate of the University of Toronto in mechanical engineering, Mr. MacKendrick was associated with the Lombard Governor Co., Sun Shipbuilding, MacIntosh & Seymour and the Mianus Diesel Engine Co. in various engineering capacities. He joined Clark in 1928 as a design engineer and served as chief engineer from 1936 to 1946, then as vice president in charge of engineering until his present appointment. He is credited with primary responsibility for the development of the "Right Angle," "Big Angle" and "Midget Angle" gas engine driven compressors. He also oversaw the development of lines of centrifugal and motor-driven compressors and the company's new gas turbine. Mr. MacKendrick is a member of the American Society of Mechanical Engineers. New vice president of engineering is **Edward G. Beardsley,** who was formerly chief engineer.

♦

Francis J. Gaffney has been appointed director of engineering of the Guided Missiles Div. of Fairchild Engine and Airplane Corp., Farmingdale, L. I., N. Y. Mr. Gaffney received his B.S. degree in electrical engineering from Northeastern University in 1935 and did graduate work at Tufts and MIT before joining the staff of the MIT Radiation Laboratories. During



Let air give your production problems a lift

Yes, let the tireless muscles of *air power* do your heavy work for you—let air be the force for pushing or pulling . . . lifting or lowering . . . opening or shutting in your plant.

Air is quick, convenient — and it will save you money, too. Try Schrader Air Cylinders to give you that push . . . or pull . . . or push *and* pull smoothly, quickly, and with less work than any other method you've ever tried.

Schrader Air Cylinders are ideal for any application where you need straight-line forces for any distance from inches to feet . . . at forces from less than 20 pounds to over 5,000 pounds. And they pack more power for their size and weight than any other commonly used type of power unit.

So—wherever you need a hefty push—or a gentle shove—or anything in between—think of Schrader Air Cylinders.

The possible uses of Schrader Air Cylinders in industrial plants are so numerous that it is impossible to do more than suggest their great utility and versatility. We'll be glad to give you specific recommendations, however, if you'll just write, outlining the processes used in your plant—or fill out the coupon below.

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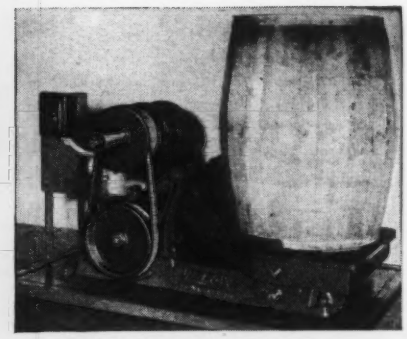

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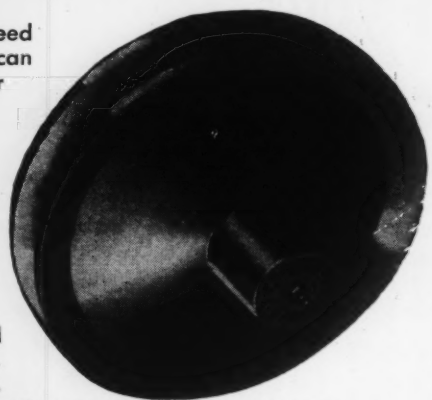
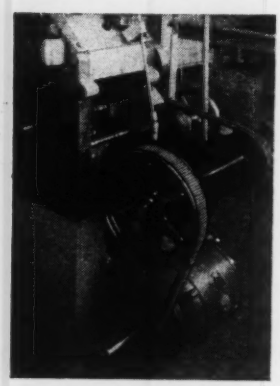
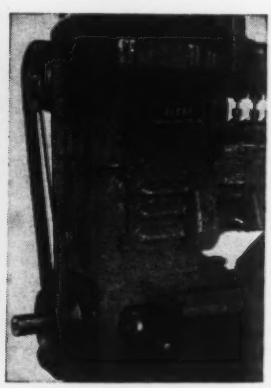
No stops for speed changes — you can quickly speed up or slow down machinery to meet changes in production routines and varying condition of materials. Yes, Lovejoy Variable Speed Pulleys get the most out of your equipment — provide simplified speed changes that save you time and money. They're easy to install on old or new equipment, too.



Sizes fractional to 8 H.P. Ratios to 3:1 infinitely variable. Low cost. Deliveries from stock.



Lovejoy countershaft Unit controls speed of automatic Spring Coiler.



Lovejoy Wide V-Belt Pulley provides infinitely variable work-speed control on Tapping Machine.

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Lovejoy Universal Joints and Lovejoy Flexible Couplings

Men of Machines

World War II he headed the Test Equipment Group in the Laboratories, developing radar and microwave equipment. After the war he joined the Polytechnic Research and Development Co. as chief engineer and became general manager in 1950, the position which he held until his new appointment. Mr. Gaffney will now have broad responsibility for all phases of the engineering program of the Guided Missiles Div.

♦

The 1952 Lamme Gold Medal will be awarded to **I. F. Kinnard,** engineering manager of the meter and instrument department of General Electric Co. at West Lynn, Mass., for his "outstanding contributions in design and developments in instrumentation and measurements." Presentation will be made during the Summer General Meeting of the American Institute of Electrical Engineers.

♦

Samuel S. Board Jr.

New director of research at the Buffalo plant of Farrel-Birmingham Co. Inc. is **Samuel S. Board Jr.** Mr. Board received his degree in mechanical engineering from Yale University in 1938 and joined Farrel - Birmingham at the main plant in Ansonia, Conn. He completed the company's two-year student engineering course, after which he served in various engineering capacities. He was named plant planning engineer in 1945. Two years later he transferred to Buffalo as assistant director of research, the position he held until his present appointment. During the years 1942-1947 Mr. Board instructed in elementary and advanced machine design at New Haven Junior College. He is a member of the American Society of Mechanical Engineers and belongs to the Yale Engineering Society.

♦

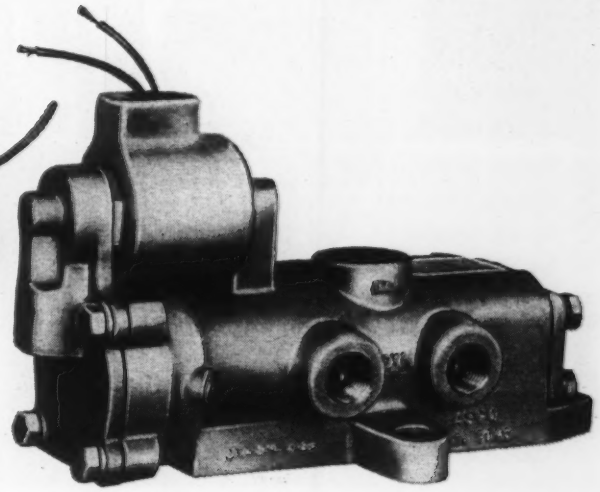
John O. Almen has joined Western Gear Works as an engineering consultant, to be located in the Lynwood, Calif., plant. He was formerly associated with General Motors.

♦

Frederick K. Powell Jr., vice president in charge of engineering of American Machine & Foundry Co., New York, recently received an Honor Award for Distinguished Service in Engineering from the University of Missouri. Mr. Powell's award cites his contributions to national defense, atomic power plants and industrial labor saving devices as well as "his skill in the design,

Announcing

The New "Super-Duty"
4 Way Poppet Type
High Speed Solenoid Valve
Produced by ASCO



Headquarters for Solenoid Valves and Electromagnetic Controls

Type

4 Way Valve, Screwed Pipe Connections or Manifold Mounting.
Available for 5 ported operation and regulated flow control.

Use

Controlling Ultra High Speed Double Acting Pneumatic or Hydraulic Cylinders.

Operating Speed with Air, 500 Cycles/Minute Continuous;
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Design Features

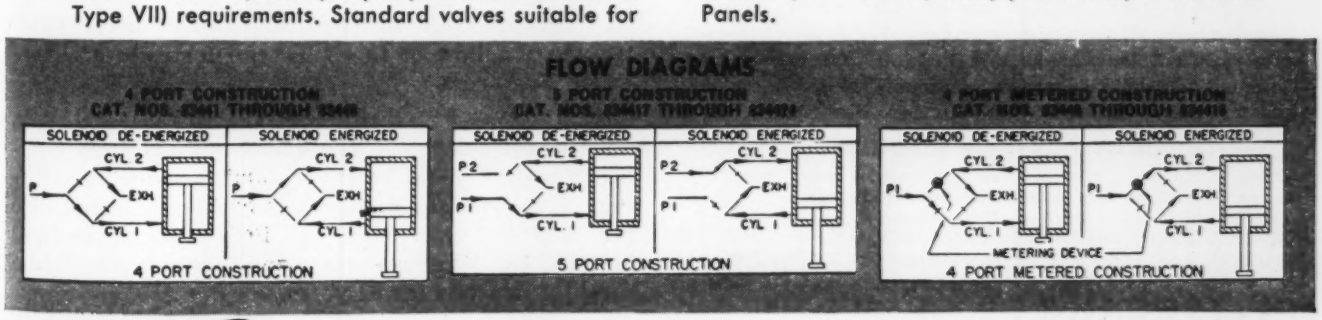
- **Instantaneous Action.**
- **Poppets on Common Shaft operated by line pressure inherently provide simultaneous valve action and tight seating.**
- **Differential Piston provides power operation in both directions. Eliminates all danger from sticking.**
- **Short Strokes; Guided Inserted Seats; Minimum Wear.**
- **Packless Construction—No Stuffing Boxes or Sliding Glands.**

This Solenoid Valve has been thoroughly tested at High Speed for millions of operations.

This Valve (Bulletin 8344) comes with mill type construction, corrosion-resistant bronze body and stainless steel seats and discs. Four standard sizes are available; ⅜, ½, ¾, and 1 inch. The compactness of the Valve is indicated by the dimensions of the largest (1 inch) unit; length 11½ inches, width 5⅜ inches, height 5 9/16 inches. The standard solenoid is suitable for NEMA Type IV Watertight and for Underwriters' Class 1, Group D, Explosion-Proof (NEMA Type VII) requirements. Standard valves suitable for pressures up to 250 psi, may be adapted to higher pressures, if required.

In writing for prices, delivery, and other information, tell us about your control problem. We have many other varieties of standard Solenoid Valves, and engineering facilities for designing special types should you need them.

We manufacture a complete line of standard and specialized Electromagnetic Controls. These include Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, and complete Control Panels.



ASCO Solenoid VALVES

"Serving Industry For Sixty-Five Years"

V. 53.3

Automatic Switch Co.

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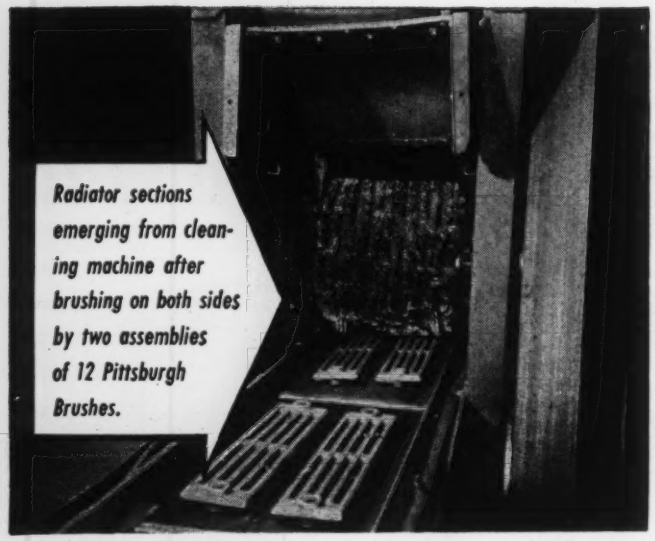

Radiator sections emerging from cleaning machine after brushing on both sides by two assemblies of 12 Pittsburgh Brushes.

Pittsburgh Brushes can help you solve problems like these!

Cleaning Narrow Spaces—National Radiator Company, Johnstown, Pa., cleans 30,000 radiator sections a week! To insure a perfect final finish, even the narrowest spaces must be absolutely clean prior to assembly. Pittsburgh engineers were asked to design a brush that would reach these spaces and would fit National's existing machine. Successful? National reports: "Pittsburgh Brushes do a better job of cleaning and are more economical."

Preparing Chills—At Continental Foundry & Machine Co., East Chicago, Indiana, chills used to cast iron rolls must be cleaned of the oxidized metal remaining from previous usage, as well as dirt and grease accumulated in storage. After experimenting with other brushes, Continental chose Pittsburgh because they "do the job better and stand up longer than any previously used."

Improving Original Equipment—The Sommer and Maca Glass Machinery Co., Chicago, Illinois, uses Pittsburgh Brushes in the automatic washing machines they manufacture. Brushes formerly used simply didn't have the over-all density pattern needed. Pittsburgh engineers studied the problem and designed a brush which Sommer and Maca approved "because of (its) denser bristle pattern and lower cost."

WRITE TODAY FOR FREE BOOKLET!

Write today for a free copy of our booklet that shows, through actual case histories, how Pittsburgh cuts brushing costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W-5, 3221 Frederick Ave., Baltimore 29, Maryland.

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Men of Machines

development and production of intricate machinery; and his remarkable ability in the field of engineering administration."

♦

John A. Borman and **Russell Hastings** have joined the Industrial Truck Div. of Clark Equipment Co., Buchanan, Michigan. Mr. Borman, who was associated with Clark from 1946 to 1950 before joining the Baker-Raulang Co., has returned as assistant to vice president **Robert H. Davies** on engineering and production problems. Mr. Hastings, who spent 18 years with the Lewis-Shepard Co., now assists in directing the activities of the Clark engineering staff.

♦

The Electric Products Co., Cleveland, has appointed **W. A. Thomas** as chief engineer, with responsibility for all electrical and mechanical design engineering, development and research. Dr. Thomas was formerly manager of electrical engineering. **E. D. Smith**, now consulting engineer, will be responsible for assigned engineering projects requiring specialized investigation and development.

♦

Nicholas A. Noreyko was recently promoted to assistant chief engineer of the Pump Div. of Eaton Mfg. Co. in Marshall, Mich. Mr. Noreyko joined the division in 1941 as a draftsman and was made drafting room supervisor in 1948. He was previously associated with the Counterbore Tool Co. and the Wiley Mfg. Co. as a die designer and maker.

♦

Chrysler Corp., Detroit, has appointed **A. E. Kimberly** chief engineer of the DeSoto Div. and **Robert Anderson** chief engineer of the Plymouth Div.

♦

Carl E. Johnson, chairman of the board of Sterling Electric Motors Inc., Los Angeles, and one of the founders of the company, died recently in San Marino, Calif. Mr. Johnson organized the first company on the West Coast for the manufacture of electric motors and generators and made many major technical contributions to the electric motor field. He was a fellow of the American Institute of Electrical Engineers.

♦

To direct telephone, radio and vacuum tube engineering for Federal Telephone and Radio Corp., Clifton, N. J., **William P. Maginnis** has been elected vice president and chief engineer. Before joining Federal in 1951, Mr. Maginnis was associated with the Radio Corp. of America for 21 years.

♦

Donald C. Burnham has been named assistant chief engineer in charge of body, sheet metal and chassis design at Oldsmobile Div., General Motors Corp., Lansing, Mich. New assistant chief engineer in charge of engine, transmission, experimental test and development is **Lowell A. Kintigh.**

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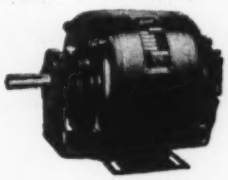
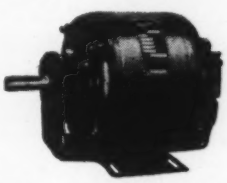
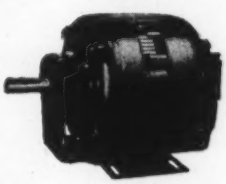


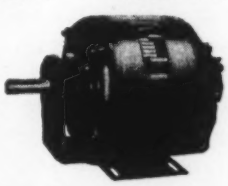
DISPOSAL UNITS • WASHERS • IRONERS



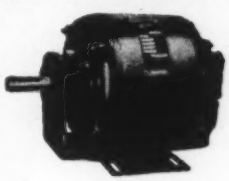
OIL BURNERS • STOKERS • LAWN MOWERS

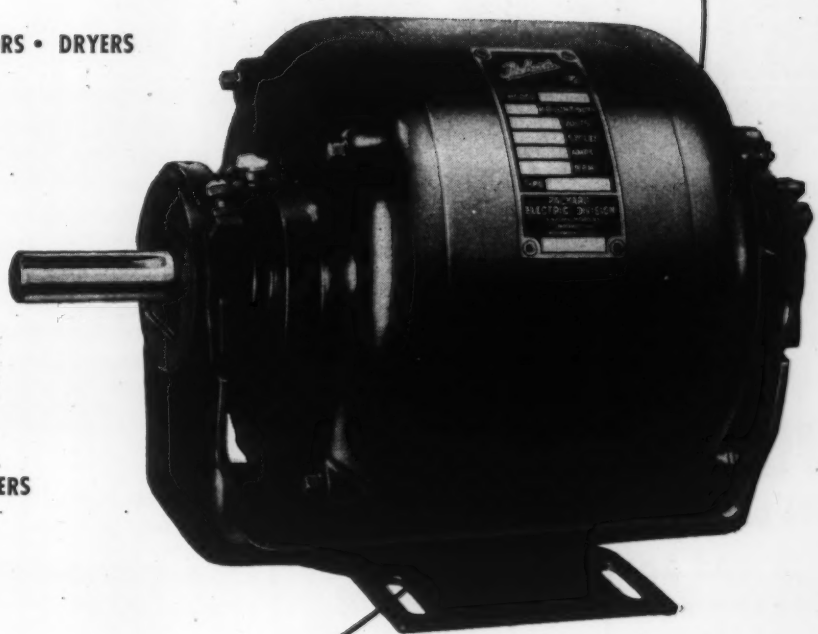


WATER PUMPS • MILKING MACHINES



CREAM SEPARATORS • VENTILATING UNITS





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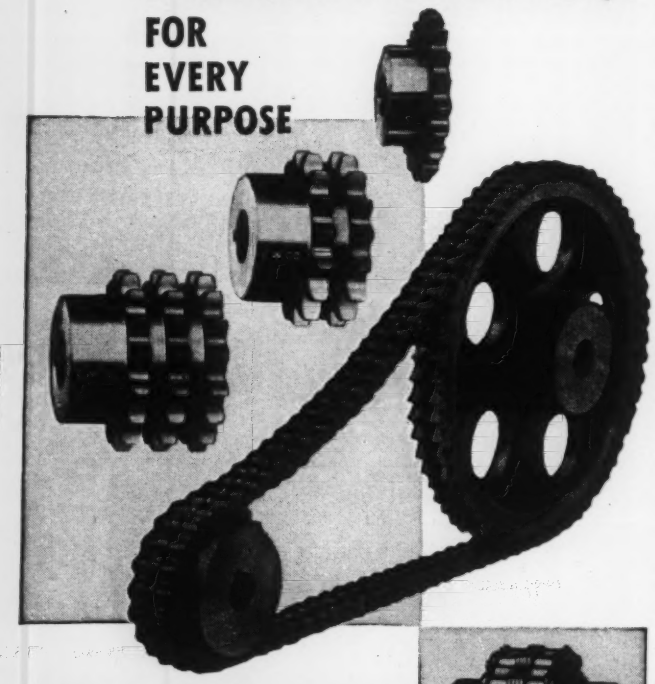

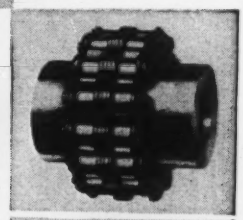

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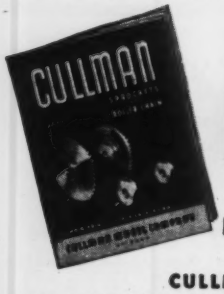

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Recent Books

Analytic Mechanics. *By V. M. Faires, professor of mechanical engineering, North Carolina State College and S. D. Chambers, professor emeritus of engineering mechanics, Purdue University;* 558 *pages,* 6¼ *by* 9½ *inches, clothbound; published by the MacMillan Co., New York; available from* MACHINE DESIGN, $6.00 *postpaid.*

The authors of this third edition present the simple particular cases first, proceeding to the general case in easy steps, and then show how particular applications may be obtained from the more general equations. The only new mechanics topics, not in the previous edition, are a chapter on vibrations and some additions in the appendix. Nearly 800 figures provide a clear understanding of many of the theories and problems introduced. Basic calculus is used with some cases since it often provides the simplest solution.

♦

Metal Data. *By Samuel L. Hoyt, technical advisor, Battelle Memorial Institute;* 540 *pages,* 7 *by* 10 *inches, clothbound; published by Reinhold Publishing Corp., New York; available from* MACHINE DESIGN, $10.00 *postpaid.*

Written primarily for materials engineers and metallurgists, this second edition of *Metals and Alloys Data Book* provides a reference source for the technical personnel of all metal-using industries. Properties of practically all commercial metals are presented in nearly 700 tables and graphs with the descriptive text kept to a minimum. The first two chapters cover test specimens and hardness testing. Metallic properties of all types of iron and steel are covered in the next five chapters. Chapter 9 embraces iron-base alloys and a comprehensive discussion of nonferrous alloys follows in the next chapter. Properties of 35 additional metals are briefly considered in Chapter 11, and general tables of weight, thickness, grain size, etc., make up the final chapter.

♦

Control of Electric Motors. *By Paisley B. Harwood, vice president in charge of engineering, Cutler-Hammer Inc.;* 550 *pages,* 6 *by* 9 *inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, $7.50 *postpaid.*

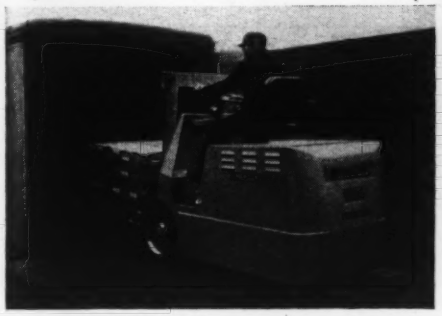
This third edition, like the previous ones, describes the design, construction, and application of controllers

Advertisement

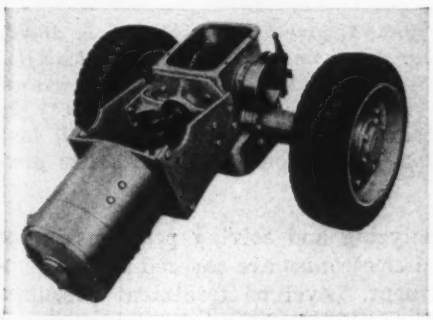
Motor Design Provides High Overload Capacity On Mercury "Yak" Trucks

Use of series wound, vehicle-type traction motors which are designed to provide high overload capacity is one of the factors contributing to the outstanding performance of the "Yak" Tilting Tiering Fork Trucks built by The Mercury Manufacturing Company, Chicago.

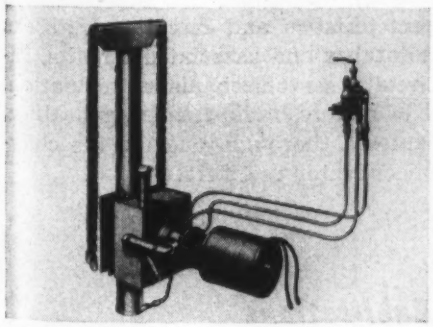
Two of these motors are used on every truck: one on the axle drive assembly, the other to drive the pump in the hydraulic hoist and tilt system.



A Mercury "Yak" Model 430 truck removing pallet load of welding wire from motor truck at receiving dock of industrial trailer manufacturing plant.

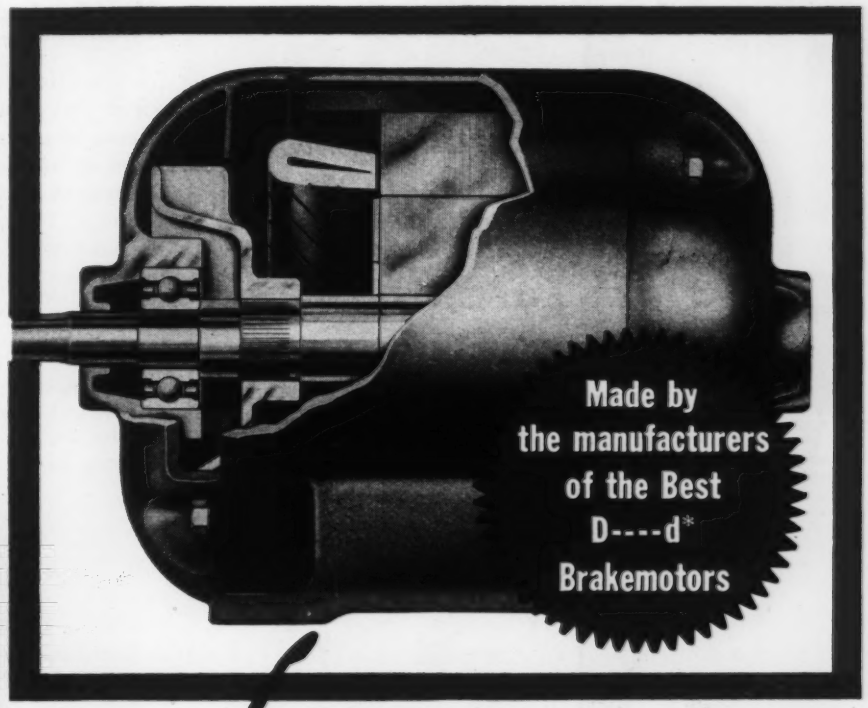


Drive axle of the "Yak" Model 430. Vehicle type motor shown at left provides high overload capacity.



A second vehicle-type series motor powers the pump for hydraulic hoisting and lowering and for fork tilting.

These high-overload capacity series motors used on every "Yak" truck are engineered and built by Star-Kimble, Motor Division Miehle Printing Press and Mfg. Co., 201 Bloomfield Avenue, Bloomfield, New Jersey. Basic information on these and other types of d-c motors is contained in Bulletin B1001, available on request from the manufacturer.



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For further information, write for Bulletin B-201

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MOTOR DIVISION

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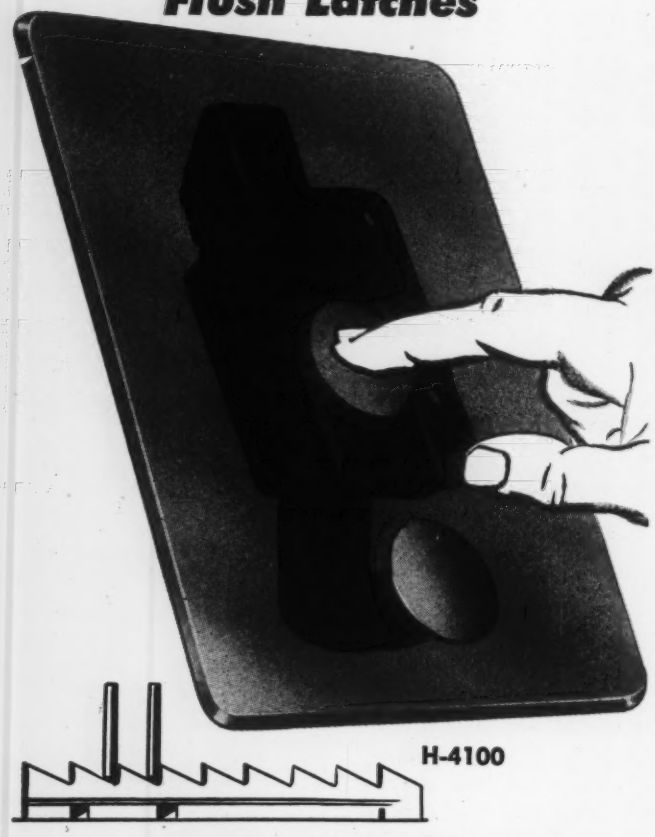

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The Engineer's Library

for electric motors and is arranged by motor types. First there is a general introductory discussion of wiring diagrams, construction details, and pilot devices as applied to all kinds of motor control. Then dc motors and their control are thoroughly discussed followed by control of ac motors. Magnetically operated brakes and motor control resistors are covered in the last two chapters.

♦

Introduction to Servomechanisms. *By A. Porter, head of research department, Ferranti Electric Ltd.,* 160 *pages,* 4¼ *by* 6¾ *inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, $1.75 *postpaid.*

Intended for the designer or engineer who is not familiar with servomechanisms, this booklet introduces the subject with basic terminology. Theoretical foundations of the field are explained by example schematics and diagrams with particular emphasis on the problems of adequate damping and small dynamic lags in the systems. Although basic equations of servo systems are brought into the discussion, physical principles rather than mathematical techniques make up the content.

♦

Industrial Electronic Engineering, *by Wells L. Davis, chief of engineering development, Babcock & Wilcox Co., and Herman R. Weed, assistant professor of electrical engineering, Ohio State University;* 526 *pages* 5½ *by* 8½ *inches, clothbound; published by Prentice-Hall Inc., New York; available from* MACHINE DESIGN, $11.35 *postpaid.*

Methods of analyzing and solving problems in the field of industrial electronics are covered in this comprehensive treatment. Level of treatment presumes that the reader has a basic knowledge of ac circuit theory, elementary theory of electronic circuits, and elementary differential equations. Subjects included are gas tube characteristics and circuits, rectifiers and inverters, phototubes and associated circuits, industrial timing circuits, servomechanisms, regulation, electronic control of motors, radio-frequency heating, and X-rays. Chapter 4 thoroughly covers the characteristics of semiconductor rectifiers.

Association Publications

Proceedings of the Eighth Annual National Electronics Conference. 864 *pages,* 6¼ *by* 9¼ *inches, clothbound; available from National Electronics Conference,* 852 *E.* 83*rd St., Chicago* 19, *Ill.;* $5.00 *postpaid.*

The 97 papers presented in 21 technical sessions of the 1952 National Electronics Conference are included in this volume. The subjects covered are servomechanism theory, high-frequency electron

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Screw Thread Manual. 62 *pages, 7¼ by 9¾ inches, paper-bound; available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.,* $2.50.

Designers and draftsmen are supplied with information concerning the selection, design, testing or making of the most commonly used screw threads with this manual. There are sections covering thread forms and formulas, standard threads, special threads, and screw-thread gages and gaging.

New Standards

Specifications for Brazing Filler Metal. *ASTM B260-52T and AWS A5.8-52T; 9 pages, 6 by 9 inches, paperbound; available from either the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., or the American Welding Society, 33 West 39th St., New York 18, N. Y., 40 cents.*

This specification standard covers every type of brazing filler metal in common use today. The 33 different classifications are divided into groups according to the principal constituents.

Government Publications

NACA Technical Series. *Each publication is 8 by 10½ inches, paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics, 1924 F St. N.W., Washington 25, D. C.*

The following Technical Notes are available:

2846. **Effective Lubrication Range for Steel Surfaces Boundary Lubricated at High Sliding Velocities by Various Classes of Synthetic Fluids**—23 pages.

2848. **Investigation of Spontaneous Ignition Temperatures of Organic Compounds with Particular Emphasis on Lubricants**—40 pages.

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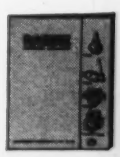

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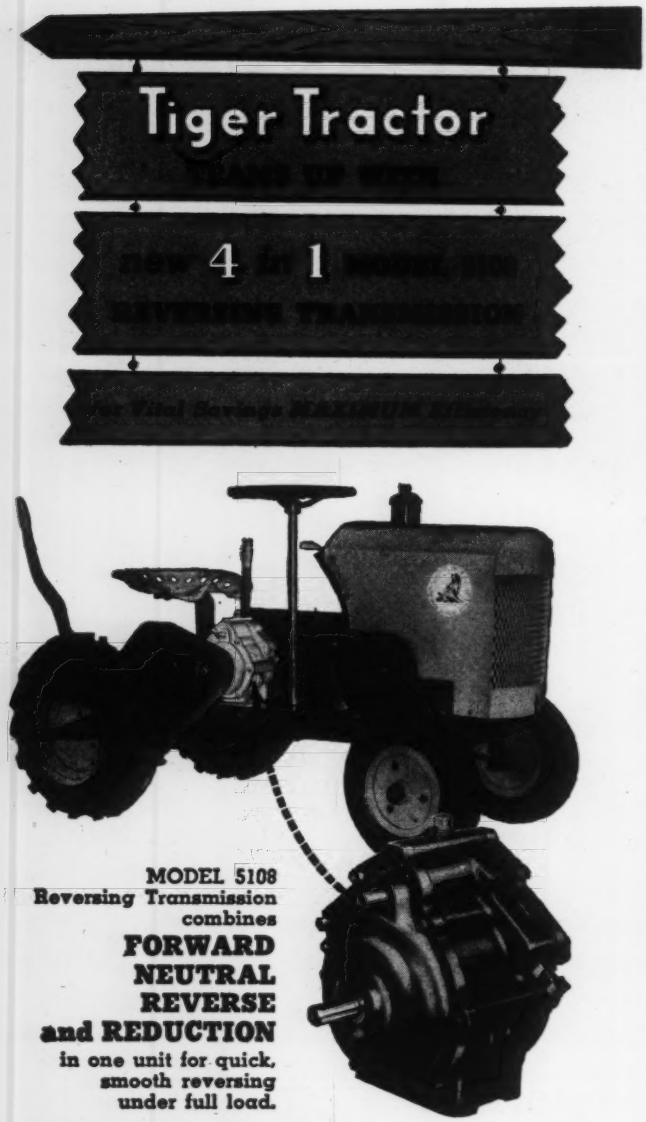

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in one unit for quick, smooth reversing under full load.

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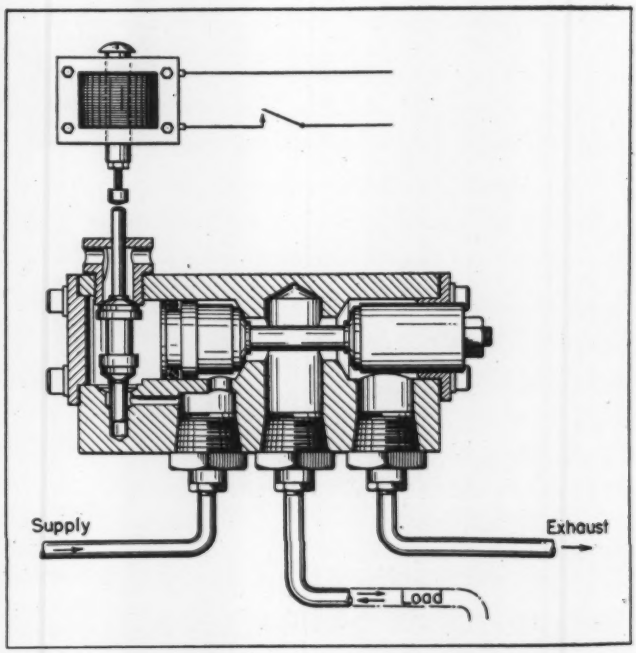
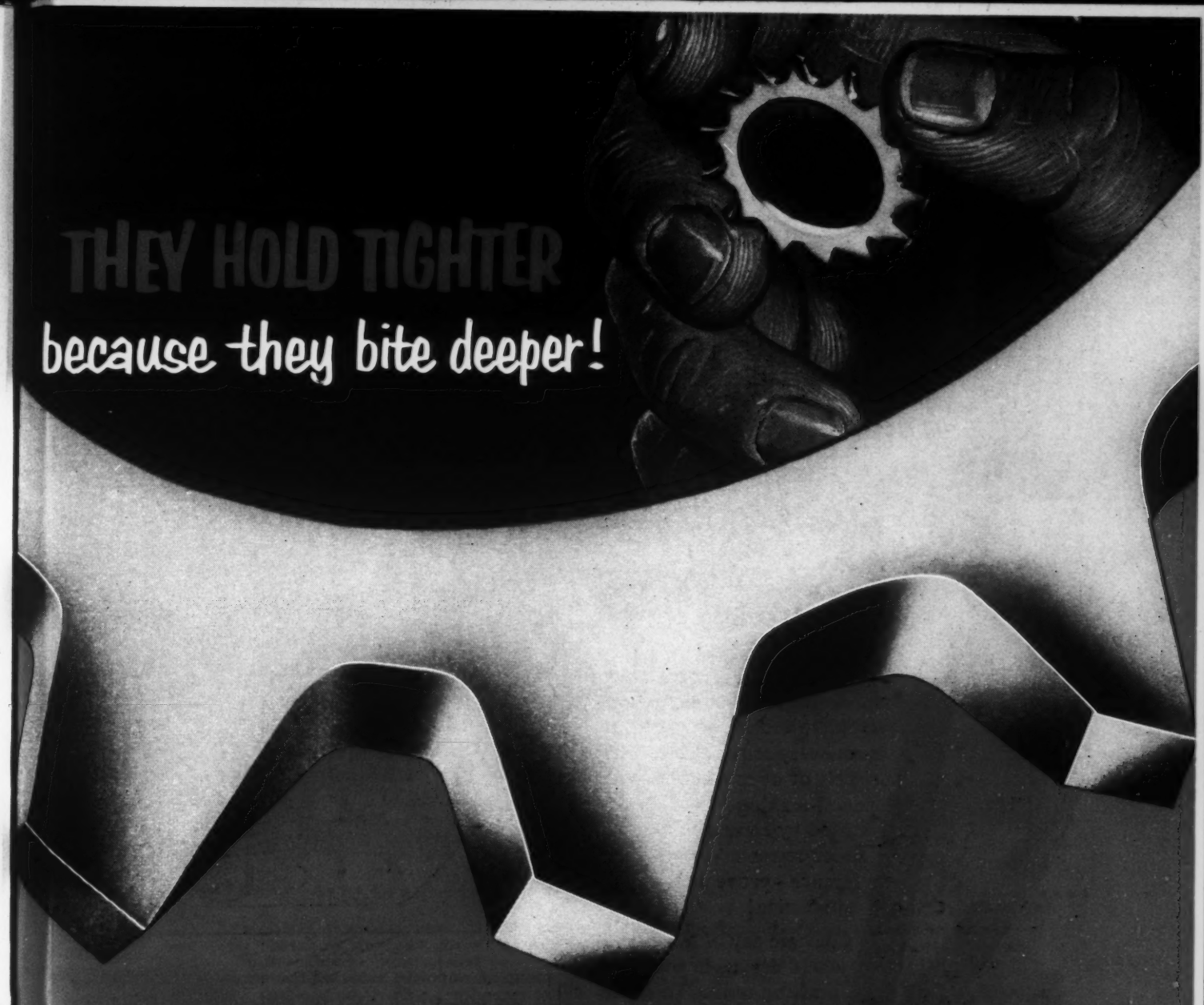
NOTEWORTHY Patents

HIGH-SPEED PRESSURE CONTROL for the operation of pneumatic or hydraulic cylinders is provided by the valve assigned to Automatic Valve Inc. by Lawrence H. Gardner under patent 2,617,444. Designed for continuous operation, the valve employs a built-in pilot to actuate a sliding plunger which controls the supply of line pressure to and exhaust pressure from the working cylinder. With the pilot closed, line pressure opens the main valve and enters



the cylinder; with the pilot open, line pressure closes the main valve and permits cylinder pressure to be exhausted to atmosphere. Valve construction reduces to a minimum the amount of fluid required for actuating the main valve. Control of the pilot may be manual or electric and speeds up to 500 cycles per minute may be attained. Modifications employing two of the valves coupled together for bidirectional cylinder actuation are also described in the patent.

AUTOMATIC FLUID RETENTION in hydraulic lines disconnected inadvertently or purposely from the supply source is provided by a bayonet fitting assigned to Deere Mfg. Co. Covered in patent 2,619,367, the fitting has been designed for use on agricultural equipment to facilitate connection and disconnection of hose lines. During normal operation, with the fitting plugged into a female coupling in the supply pressure chamber, flow into the lines is unrestricted. However, when the fitting is pulled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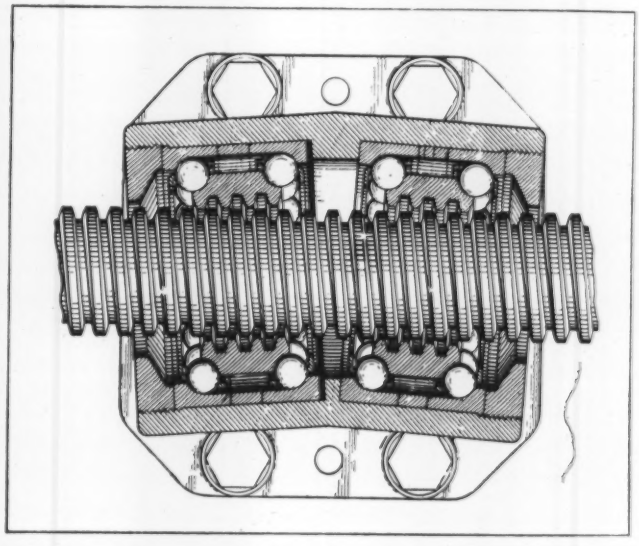
Noteworthy Patents

loose, a latch-operated, spring-loaded ball check valve is actuated to close the flow passage and prevent fluid discharge from the line. The fitting is readily inserted manually. Paul L. Hanson is the inventor.

POWER SCREW DRIVE for transmitting reciprocating linear motion reduces frictional losses 90 per cent below that of conventional screw and nut types. Covered in patent 2,616,302, the drive employs two oversize nuts, offset and mounted on ball bearings, as power transmitting members. Standard Acme threads are used on the screw and partial engagement of opposite sides of the screw with the threads in the nut, which have no lead, provides rolling contact to reduce sliding frictional losses. Backlash is readily eliminated by shim adjustment of the spacing between nuts. Described in several modifications, drive construction facilitates assembly and maintenance. The patent has been assigned to Sundstrand Machine Tool Co. by Gunnar A. Wahlmark.



AUTOMATIC SLACK TAKEUP to compensate for wear in chain drives is provided by a unique mechanism described in patent 2,625,829. Gradual tightening of a nut, achieved with a tension spring arrangement, moves an idler pulley mounted on a slide to maintain constant chain tension. Takeup adjustment is fixed in one direction and backup is prevented by friction in the nut. The mechanism may also be readily adapted to belt drives. The patent has been assigned to the New Holland Machine Div. of the Sperry Corp. by Edwin B. Nolt.

PRECISION FLOW CONTROL for hydraulic and pneumatic systems regardless of flow direction is afforded by a needle valve described in patent 2,618,457. Assigned to Taylor Instrument Co. by James R.

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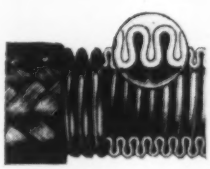
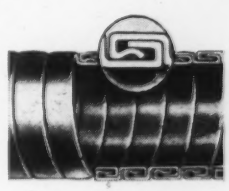
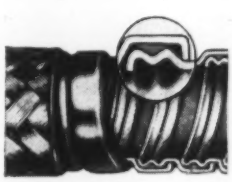


CMH corrugated hose is available with metal braid covering or unbraided in steel, bronze or stainless steel. Used where great flexibility is required at high temperatures and high pressures. Sizes range from 3/16" I.D. to 24" I.D. Depending on size, type and material, it will handle burst pressures to 12,000 psi, temperatures to 1200° F.

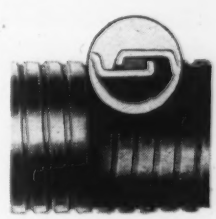
CMH interlocked hose is available in various types, packed and unpacked, in steel, stainless steel, bronze, aluminum, brass and other metals. It is used for steam, exhaust, tar and asphalt, etc. Sizes 1/2" to 12", I.D. Depending on size, type and material, it may be used for working pressures to 750 psi (constant), temperatures to 600° F.





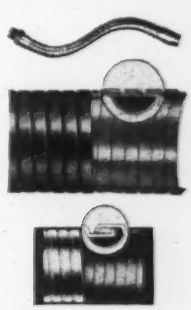
CMH double groove (ball bearing design) hose is available in bronze, steel or stainless steel with asbestos packing and with or without metal braid covering. Widely used for non-searching liquids and gases at low to moderate pressures and temperatures. Sizes range from 5/32" to 1 1/4", I.D.

CMH square locked hose is available unpacked or with a choice of several types of packing in steel, bronze, brass, aluminum, stainless steel, etc. It is used as conduit, cable armor, nozzles and many similar applications. Sizes range from 3/16" to 1", I.D. Normally used only at very low pressures.



The Flexonics Hose Design Guide gives specifications and application data on all types of CMH Flexible Metal Hose and special assemblies as well as additional data on other Flexonics products for the original equipment market. Write for your copy or see the Flexonics catalog in Sweet's Product Design File.

Standard assemblies and special purpose flexible metal hose items are manufactured for such services as steam, tar and asphalt, machine tool coolants, machine tool wiring conduit, dry granular products. We will be pleased to send data on any specific requirement.



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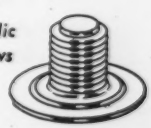
Aircraft components



Metallic bellows

the GEROTOR mechanism

"runs like

clockwork"

because it's
PRECISION
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In every GEROTOR pump or motor, precisely paired gear-shaped elements transmit power from or to the shaft with high efficiency. These elements, revolving in the same direction at low relative speed, constitute the GEROTOR mechanism . . . famed for longer life, less wear, less slippage, dependably smoother performance. With GEROTOR pumps or motors, hydraulic circuits "run like clockwork", too.

Gerotor May Corp. . . . Baltimore 3, Md.

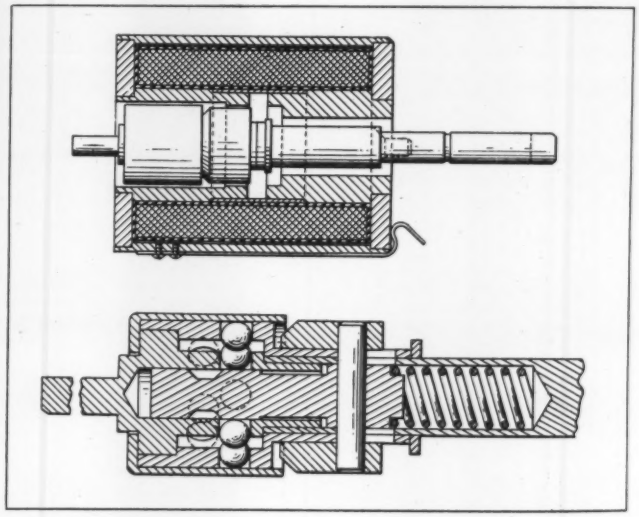
GEROTOR

HYDRAULIC PUMPS & FLUID MOTORS

Noteworthy Patents

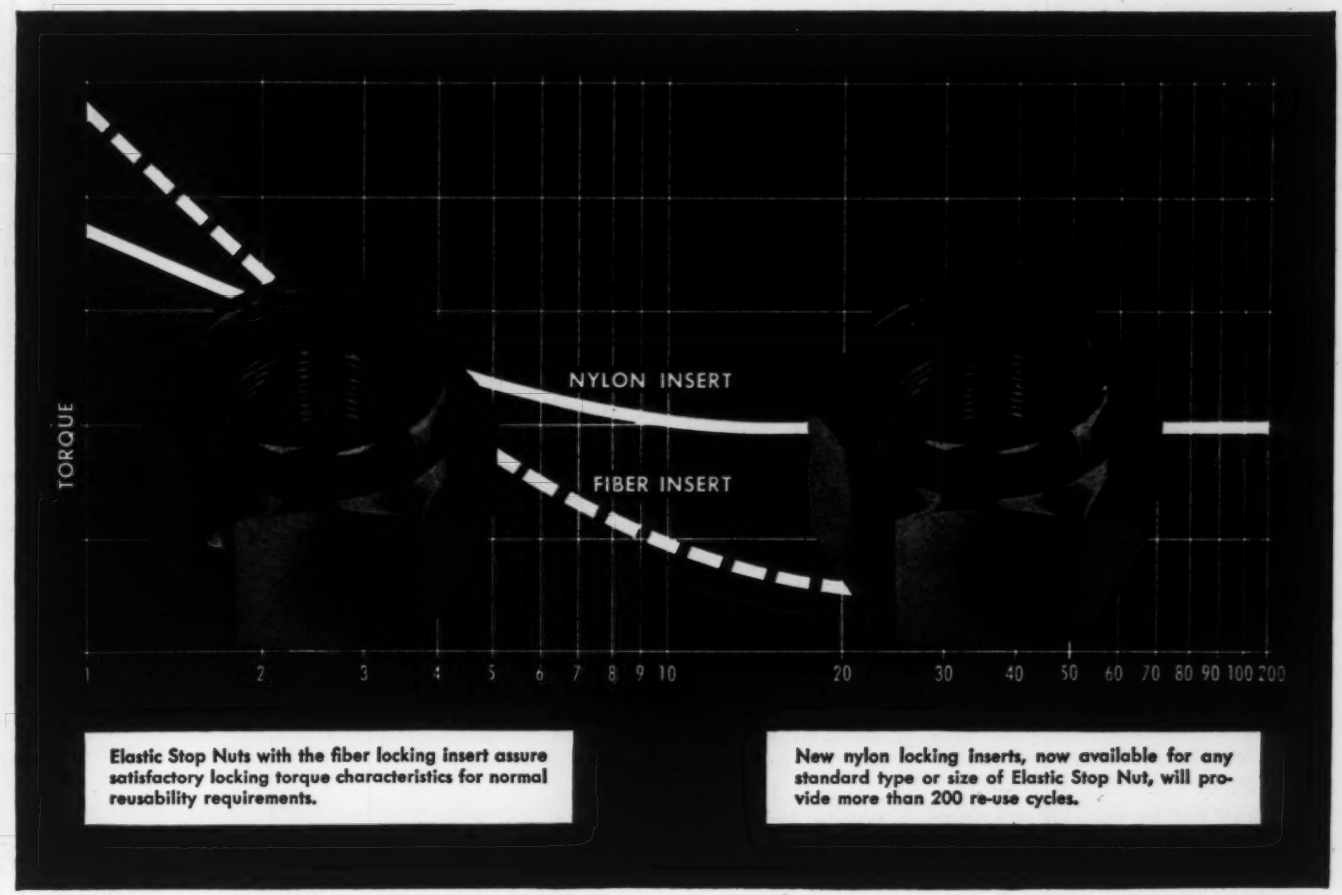
Davidson, the valve employs an enlarged conical needle, offset with its seat and attached to a spring-loaded sliding plunger, to regulate the rate of flow. Uniform adjustments in the flow rate are provided by an external adjusting screw; spring action acts to return the valve to a closed position. Design of the valve prevents jamming and scoring of the moving parts and facilitates repair and replacement.

RELATIVE ANGULAR POSITIONING of two rotating members is provided by a step coupling assigned to Alden Products Co. under patent 2,621,494. Invented by Edward D. Cross, the coupling has been designed as a mechanical shaft connection for use with facsimile recorders to insure synchronism between drums at the sending and receiving stations. Power is transmitted to the driven member through



ball keys arranged in two rows which are out of phase angularly. A sliding plunger cam controlled electromagnetically determines which row is in driving contact. Variations in phase relationship are obtained by varying the cam position, each change in position causing an angular slip of 45 degrees between the rotating members.

POSITIVE ENGAGEMENT for spring clutches is assured by a unique drum construction detailed in patent 2,615,543. A wafflelike grid on the contact surface of the drum minimizes the force which must be exerted by the engaging spring to break through the lubricating oil film and establish metal-to-metal contact. As torque increases, the friction force resulting from this surface contact acts to further tighten the spring and make the drive more positive. In addition, the grid pattern has been designed to provide uniform contact pressure distribution and wear over the drum surface. Assignee of the patent, which was invented by Mieth Maeser, is the United Shoe Machinery Corp.



Elastic Stop Nuts with the fiber locking insert assure satisfactory locking torque characteristics for normal reusability requirements.

New nylon locking inserts, now available for any standard type or size of Elastic Stop Nut, will provide more than 200 re-use cycles.

How do you measure Reusability?

UP TO FIFTEEN TIMES?

For assemblies that must be locked in place, Elastic Stop Nuts with fiber locking inserts guarantee a permanently secure grip—plus ample reusability to cover most normal maintenance requirements.

For assemblies that must be disassembled and reassembled five, eight, ten, or more times during normal use, fiber insert Elastic Stop Nuts make the ideal self-locking fastener.

When an Elastic Stop Nut is run on a bolt, the Red Elastic Collar hugs the bolt—actually makes a skin-tight fit against the entire contact length of the threads—and this controlled torque firmly resists vibration or shock. When the Elastic Stop Nut is removed from the bolt, the natural resiliency of the Red Elastic Collar is your guarantee of continuing torque when the nut is reapplied.

MORE THAN FIFTEEN TIMES?

Now, for assemblies that require constant adjustment or frequent disassembly for checking and maintenance, ESNA offers all standard types and sizes of Elastic Stop Nuts with the new nylon locking inserts.

Reusable up to 200 times with remarkably constant torque characteristics, these new Elastic Stop Nuts offer the one-piece construction, the shock resistance, and the moisture-seal features that many manufacturers now depend upon in the standard Elastic Stop Nuts.

One of these Elastic Stop Nuts is probably the solution to your most troublesome fastener problem. It will pay you to look into the self-locking performance of Elastic Stop Nuts. For information, write for a new, free booklet. **Elastic Stop Nut Corporation of America,** 2330 Vauxhall Road, Union, New Jersey, Dept. N5-54

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ELASTIC STOP NUTS

NYLON AND FIBER INSERT TYPES ARE QUALIFIED TO SPEC. AN-N-5

Engineering News Roundup

Mathematicians Needed To Help "Brain"

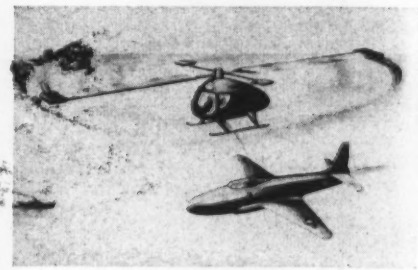
A new electronic calculator will perform an average of 14,000 mathematical operations per second; it can solve problems involving partial differential equations, ordinary differential equations, integral equations, matrices and combinatorial analyses. Eight million calculation steps can be completed and a solution found in minutes to a problem which would require seven years of calculation by a man with a desk computer. But the manufacturers of the "brain" feel that there may not be enough top quality mathematicians to prepare problems for the dozen or more of these machines which they expect to build this year. An estimate places the number of mathematicians necessary to keep the machines busy for the next year at about 2000.

Composed of 11 compact connected units, the first of the machines has been installed at the world headquarters of the manufacturer, International Business Machine Corp. in New York. The entire unit is called the "701" and is claimed to be the first calculator of comparable capacity to be produced in quantity. Rental of the units will range from $11,900 to $17,000 per month depending upon storage capacity or number of "memory" units required for a particular application. Those to be built this year are all consigned to government agencies or defense industries.

Three types of storage units are used: electrostatic, magnetic drums and magnetic tapes. Electrostatic memory units are small cathode ray tubes which can store the equivalent of 20,000 decimal digits on their screens as spots of light. An electron beam "looks at" the spots and converts them into electronic impulses. Magnetic drum capacity is 80,000 decimal digits; magnetic tapes store 2 million digits each.

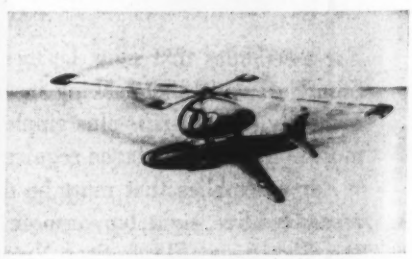
Completed calculations can be printed at the rate of 1050 ten-digit numbers per minute, recorded on tape at 1250 ten-digit numbers per second, or punched on cards at the rate of 2400 ten-digit numbers per minute.

One small but highly important point, the decimal point, received truly deserved recognition in the design of this computer. Users of the machines need not be concerned with proper placement of the decimal point in a solution involving millions of sequential steps. The brain knows where the decimal point belongs and reports its position as results are printed.



Helicopter Tugs For Airplane Pickup

Helicopters may someday be used to launch and land fast-flying jet transports in the hearts of large cities. Dr. J. A. J. Bennett, assistant to the Chief Engineer, Hiller Helicopters, recently proposed such a plan and pointed out that present experience in refueling aircraft in flight and with carrying heavy underslung loads by helicopter has already solved many of the problems involved.



Aircraft to be launched would be lifted vertically to a safe altitude for launching and launched at a speed within the speed ranges of both helicopter and fixed-wing aircraft. The take-off procedure would be reversed for landing. Ram jet helicopters with their high load carrying capacity for relatively short lengths of time are felt to be best suited for such an application.

Helicopter launching and landing would eliminate the necessity of long runways and make possible operation of high speed aircraft from almost any ship. A pilot thoroughly familiar with the particular

locale would be in charge of take-off and landing just as a harbor pilot is responsible for guiding large ocean liners in and out of port.

Low-Pressure Balloons for Vehicles on Uneven Terrain

Soft, fat, low-pressure Rolligons, replacing conventional tires on a Navy Jeep, have satisfactorily completed trial runs. The watermelon-shaped balloons support the load of a vehicle and allow it to roll over the surface of the ground. Axles hold the Rolligons in position, but do not drive them in the manner that automobile wheels are driven. Each Rolligon is driven by a series of rotating rollers on the under side of the vehicle carriage.

Molded by Goodyear Tire & Rubber Co., Rolligons are composed of one ply of rubberized fabric topped by a quarter-inch layer of gum rubber tread stock. They are inflated with air pressures of only 1½ to 5 pounds.

Intended to supplement rather than to replace tires, Rolligons enable the vehicle on which they are mounted to operate easily and without springs on soft ground and over obstructions. Inventor - designer William H. Albee expects them to find wide application in military service, industry and agriculture, inasmuch as they can be driven safely and comfortably over soft, unstable or rough ground, through sand, snow, marshes, swamps, mud, ice and rocky fields.

Tests were conducted using a Jeep as the power plant because this vehicle imparts power to each of its wheels. Also, the differentials in both front and rear axles permit one Rolligon to roll at a different rate of speed than the other, thereby facilitating steering. The test vehicle was modified by removal of its original wheels, springs, shock absorbers and all unnecessary components. It was then mounted on frames in which the Rolligons were set horizontally in place of conventional tires, axles and springs.

A Rolligon runs over its inventor demonstrating the ability to "swallow up" obstacles because of extremely low forces per unit area

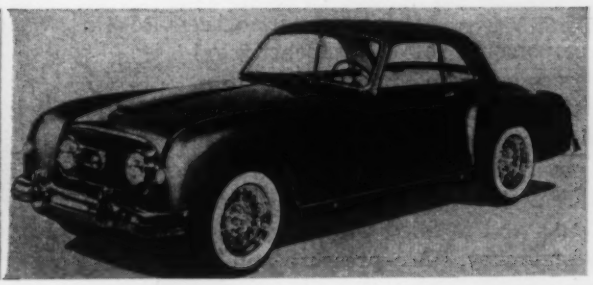
Preliminary trials indicate that loads of many tons may be transported with ground bearing pressures as low as 1 psi, and that vehicles equipped with Rolligons will develop more than half their weight in drawbar pull on loose, dry sand.

New Finish Rivals Porcelain

A silicone resin base finish, which combines extreme surface hardness with flexibility, has been developed by the Glidden Co. The company claims that characteristics of the new product, designated Nubelon S, are such that it may well replace porcelain and galvanizing on many applications, such as kitchen and laundry appliances, screening and hospital equipment. Wire coated with Nubelon S can be fabricated into bent or woven forms without chipping the surface, providing protection which costs less than galvanizing.

Primary problem in the development of Nubelon S was the natural tendency of organic finishes to lose flexibility with increase of surface

NEW SPORTS CARS: Two of the latest models to enter the sports car field are Chrysler's D'Elegance, left, and the Nash-Healey LeMans, right. The two-passenger D'Elegance has a FirePower V-8 engine and a pushbutton-operated mechanism which lifts the cover of the spare tire, which is mounted on the rear deck, and lowers the tire behind the bumper. The LeMans hardtop is powered by the Dual Jetfire Nash Ambassador 140-hp engine. It features 'trailing link' front suspension for good road holding and cornering performance



hardness and resistance to abrasion and, conversely, the loss of surface hardness with an increase in flexibility. A modification of silicone resins resulted in a baking enamel hard enough for use on home appliances, yet flexible enough to offer the possibility of application before forming the metal.

In tests comparing one coat of Nubelon S with two coats of alkyd amine systems, the Nubelon S scored "excellent" resistance to hardness, abrasion, flexibility (no cracking at 60 lb-in. impact), salt spray, humidity, hot soap and grease vapors, various stains, and heat.

The new coating is more expensive than current standard baking enamels and requires curing at 425 F, but it is 50 per cent harder than these enamels and, according to its producer, compares favorably in cost with porcelain.

Largest Vibrator Controlled with Mercury

A new high capacity vibrator, believed to be the largest of its kind in existence, was recently installed in the Naval Ordnance Environmental Laboratory. The table measures 5 by 6 feet and can hold a 6000-pound load. Maximum available reaction force is 50,000 pounds. Vibration frequency can be varied from 300 to 5,000 cycles per minute by varying the speed of the 30-horsepower dc driving motor.

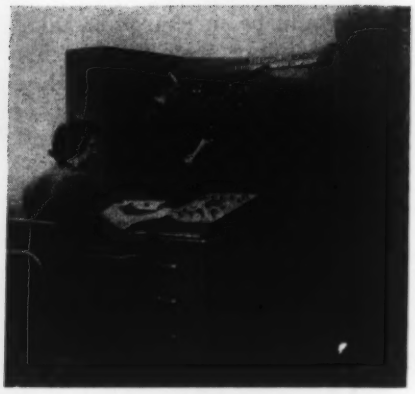
Mercury is used in a unique manner to produce and vary the centrifugal force which produces the vibration. Two rotors mounted on the underside of the table are driven in opposite directions through gears and universal joints from the drive motor to produce vibration. As these rotors revolve in opposite directions, horizontal components of the centrifugal forces produced by their rotation balance out, leaving only the desired vertical forces. Each rotor is a hollow cylinder divided into three chambers by radial partitions, and is filled with 84 pounds of mercury. Air pressure applied to two of the chambers causes some of the mercury in those chambers to be transferred to the third chamber, resulting in an asymmetrical distribution of mass and centrifugal force, proportional to the air pressure difference in the chambers. This allows reaction force to be varied independently of the frequency.

Despite its size and weight, the vibrator can be raised on casters and rolled to other locations. Other features of the new vibrator are force-feed lubrication for the rotor bearings and forced-draft ventilation to cool the oil and other moving parts.

4 Million Computations Completed Without Error

After successfully completing 60 hours of nonstop tests, a commercially available "robot brain" electronic computer has been accepted by Army Ordnance officials at Aberdeen Proving Ground—the first of its type to perform without error for as many hours on its test run. Making errorless computations at the rate of 1700 a minute, the Underwood Elecom 100 computer completed 4,212,000 computations in the first 42 hours of operation.

In operation, the machine will run continuously even though an operator is not present, and will be



equipped with a protective device to turn off the current automatically in case of any possible error or stoppage.

The Elecom 100 consists of three units: a conventional type office desk at which the operator sits, a compact "memory" unit and the computer proper which is housed in five steel cabinets joined in a semi-circle. It operates on standard 110 volts ac. The machine's magnetic memory capacity has been compared to the 4 billion memory cells of the human brain. It can store over 100,000 nine-digit number groups.

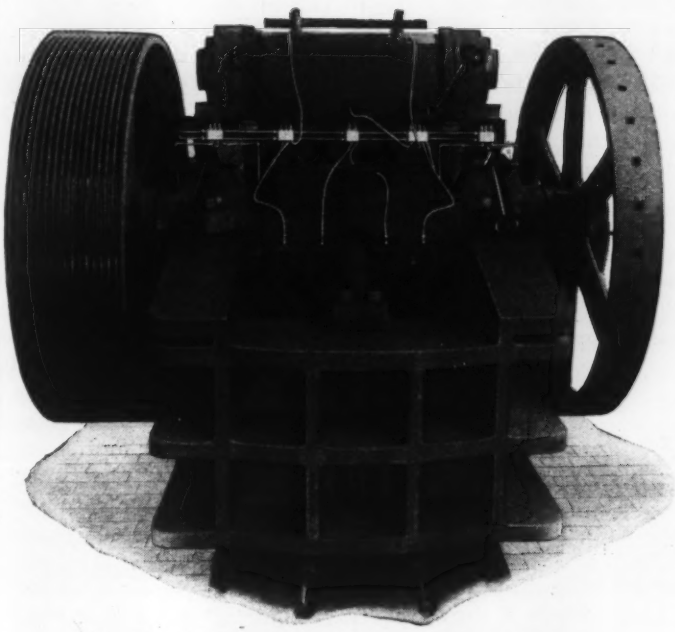
These machines will be used by aerodynamics engineers to pretest designs of new supersonic aircraft without the need of hand-built models or huge wind tunnels, and by metals engineers to study stress analysis of high-strength alloys.

•

GIANT FORGING: The world's largest steel forging, measuring 110 feet, is one of 18 rectangular column sections for a 50,000-ton die forging press being built by the Loewy Construction Co. Main body width of the forging is 44 inches; it is 100 inches wide at the ends, 16 inches thick throughout, and weighs 145 tons. The press will have six columns, each composed of three of the rectangular forgings

Dust-proof lubrication of Traylor jaw crusher insured by Farval

FARVAL—*Studies in Centralized Lubrication* No. 141



KEYS TO ADEQUATE LUBRICATION—Wherever you see the sign of Farval—the familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine will be properly lubricated. Farval manually operated and automatic systems protect millions of industrial bearings.

Photo of Farvalized jaw crusher by courtesy of Traylor Engineering Company.

YOU can't fool a rock crusher with grease cups and wick feeds. Sooner or later, dirt clogs these devices and gets into the bearings. Abrasive dust cuts. Shutdowns occur. Production stops.

The builder of this 48″x 60″ jaw crusher didn't take chances with bearing troubles. He chose a foolproof Farval system. Centralized lubrication keeps bearings at top operating efficiency and sealed to repel invasion of dirt and dust.

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, as often as desired. The Farval valve has only two moving parts—is simple and sure. No springs, ball checks or pin-hole ports to cause trouble. Farval lubricates while the equipment is working—keeps bearings cool regardless of the kind and quantity of material being crushed. And Farval completely eliminates the need for a hand oiler to clamber over slippery surfaces. Lubrication is safe, sure, cheap—saves labor, production time, bearing expense and lubricants.

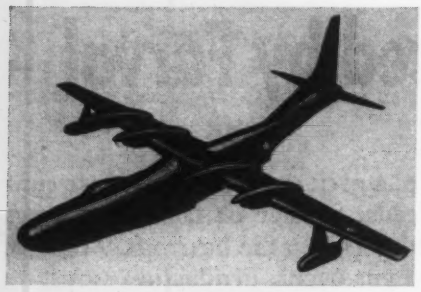
With industry moving at high speed, more and more builders and users of machinery and industrial equipment of all kinds look to Farval for continuous bearing protection—low-cost positive protection that has been a Farval trade-mark for over 26 years.

There's a specific Farval system suitable for almost any type and size machine. For information and help, consult the Farval engineer who's near you to serve you. Or write for Bulletin 26. You'll be amazed at the savings in labor, lubricant, and increased bearing life Farval can bring. The Farval Corporation, 3265 E. 80th St., Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

Engineering News

New Transport Seaplanes Fly Fast, Carry Big Loads



Designed to cruise long distances at nearly double the speed of present transport flying boats while carrying the same or greater payloads, a fleet of Convair R3Y-1 "Tradewind" transport seaplanes will be ready for trans-Pacific Navy service in 1954. Top speed of the new transports exceeds 350 mph; on the longest legs of the Navy's transoceanic air supply routes a substantial payload can be hauled at approximately 300 mph.

The 80-ton turboprop transports are the first flying boats to be equipped with air conditioning and high altitude pressurization systems. They can carry both seated and litter patients in addition to troops and cargo.

Built-in, multicell compartmentation below the cabin floor provides water tightness and leaves the cabin free of bulkheads and other obstructions which hinder cargo and passenger accommodations in large seaplanes. Magnesium is utilized in the sturdy, light-weight cargo decks. In addition, cargo compartments are lined with a non-water-absorbent material.

Tradewind transports have a wingspan of approximately 145 feet, are 142½ feet long.

Atomic Sub Engine Successful in Land Tests

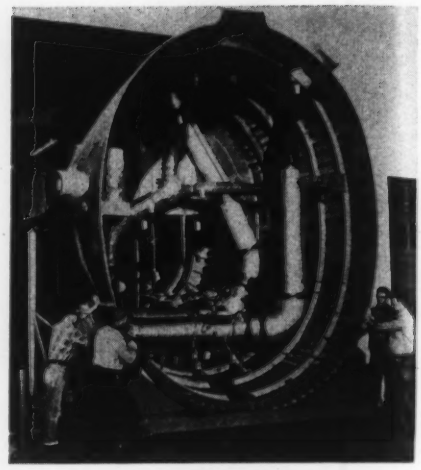
A duplicate of the atomic reactor to be used in the first atom-powered submarine, the *U.S.S. Nautilus,* has been successfully placed in operation in Idaho. Now in the first phase of operation, the reactor is sustaining an atom fissioning chain reaction. Testing and operation will continue until the reactor is brought to full power to determine operating characteristics and train the crew of the *Nautilus.*

Navy men predict that the *Nautilus* will be able to cruise thousands of miles without refueling, dive deeper and stay submerged longer than any conventional sub afloat. Uranium fuel with energy equivalent of 200,000 gallons of fuel oil per pound makes such performance possible.

Plating Process Conserves Critical Nickel

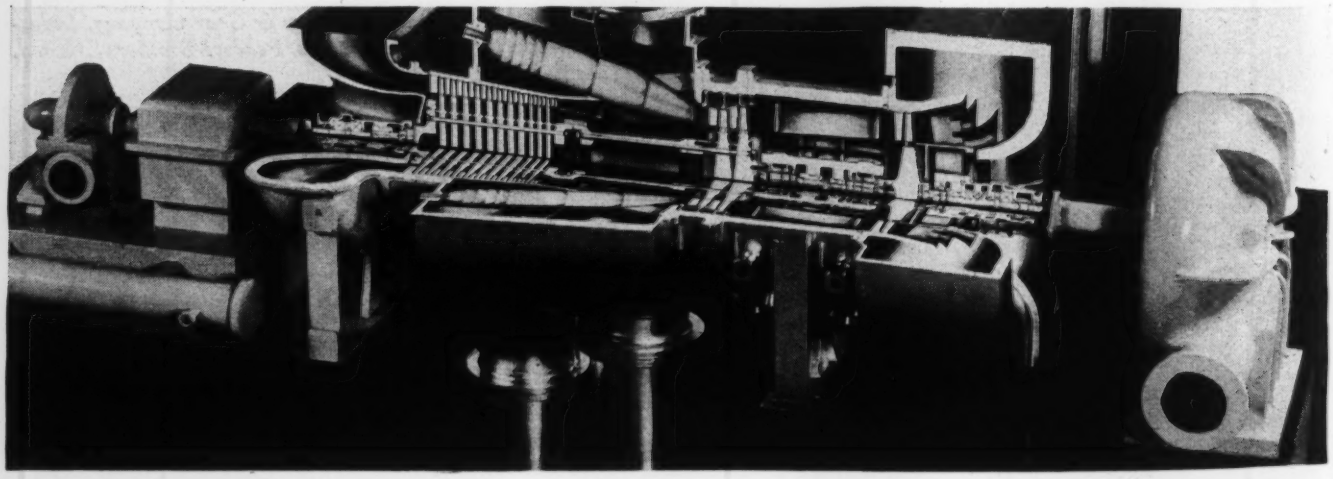
Uniformity and nonporosity of nickel coatings deposited by a new plating process make it possible to provide equal protection though the amount of nickel required is one-third to one-half that required by other processes. In addition, it is predicted that the process may be used to plate almost any solid substance, metal or nonmetal. It has already been successfully used for plating steel, stainless steel, copper, brass, bronze and aluminum. Tests made on glass, plastics and magnesium indicate that these materials may also be plated.

Known as the Kanigen process, it was developed by General American Transportation Corp. to coat the interiors of tank cars used to carry corrosive chemicals or mate-



POWERFUL HEATERS: Two jet-like gasoline heaters in the tail stub assembly of the Douglas Globemaster C-124 produce enough heat to warm a dozen six-room homes. The heaters de-ice the tail surfaces and warm the interior of the transport, which has a capacity of 200 fully equipped troops or 76,000 pounds of cargo. Chrysler's Los Angeles plant makes the wing, tail and fuselage assemblies for the aircraft

MODEL GAS TURBINE: This cutaway model of a gas turbine for pipeline pumping will be displayed by Westinghouse Electric Corp. at the International Petroleum Exposition in Tulsa, Okla.



rials which should not be contaminated by the tanks. Deposition is chemical rather than electrical. The coating is a nickel and nickel-phosphide composition. Phosphorous content is from 5 to 8 per cent of a normal coating.

Vickers hardness number of the plate is 550 to 650 (535 Brinell). As might be expected, the coating is extremely brittle and has very low ductility; it is not recommended for parts which will be subjected to considerable flexing. Coating thickness is uniform within 10 per cent and porosity is virtually nonexistent at thicknesses of 0.0005-inch. Excellent adhesion has been demonstrated by pulling plated steel specimens to the breaking point in a tensile machine with no signs of flaking or chipping. Corrosion-resistance of Kanigen plate approaches that of wrought nickel; a plated piece can be used under any conditions under which wrought nickel would serve.

One of the most important features of the process is its ability to plate any place that can be reached by the plating liquid even on the most intricate and irregularly shaped parts, with uniformity and no buildup. Parts such as screws, gears and intricate castings can be given a uniform coating.

June Engineering Graduates Have Wide Job Choice

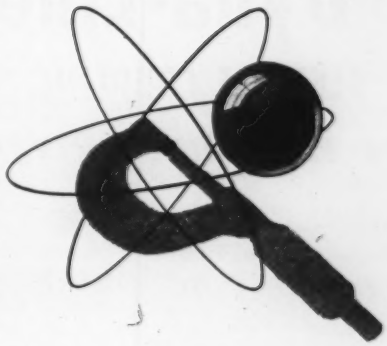
June graduates who have earned degrees in engineering have a wide choice of jobs awaiting them. At Stevens Institute of Technology, for instance, 195 students will graduate in June, 145 of whom are not committed to enter the armed services immediately; these graduates have received job offers from 172 companies. The University of Idaho reports that personnel men have come seeking "engineers by the thousands."

A report from Northwestern University shows that beginning engineering salaries are the highest in any field, the national average being $325 a month, whereas the average for all fields is $304. Offers made to Stevens students average $400 a month, with some as high as $500. However, rather than seeking the highest salaries, students are looking for jobs they will enjoy in an industry which has a future, according to Harold R. Fee, director of placement at Stevens. He says that most graduates are most attracted to the electronics, aircraft, chemical and petroleum industries.

Men who are entering military service are receiving offers to begin work after their discharge, which is an indication of the continuing shortage of engineers. Although over 51,000 new students—the third largest class ever to enter engineering schools—enrolled in the fall of 1952, the U. S. Office of Education estimates that, assuming natural progression, 1956 graduates will number only about 30,000. The ROTC will claim approximately 40 per cent of these graduates, and others will be called by Selective Service. Thus, the actual number of 1956 graduates available to industry will not greatly exceed the predicted low number for each of the next three years.

Companies surveyed by Northwestern University reported that only 68 per cent of their needs for engineering graduates were met in 1952. Based on estimates of the Office of Education, 55,000 graduate engineers will become available to industry during the next four years. Industrial and governmental civilian need for engineers, estimated now at 40,000, will continue to mount at the rate of 30,000 a year during the current decade, which will result in a deficiency of 105,000 engineers by 1956.

One step taken toward alleviating this shortage is a program evolved by the University of Dayton, embracing a three-point program of testing, interpretation and summer refresher courses. This spring, the university also offered free engineering aptitude tests to all high school students interested in engineering. Recent national surveys have shown that over one-third of the students who are admitted to engineering schools need some type of refresher work. One of three freshmen drop out of engineering by the end of the first



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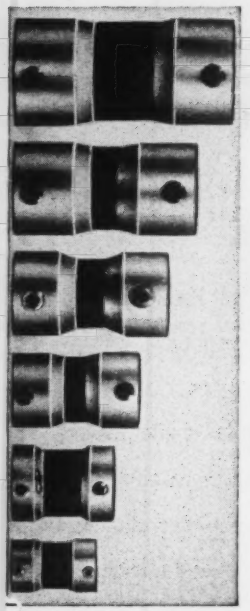

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Engineering News

year, the major reason being poor preparation.

After a student has received his test results he knows whether or not he will need refresher courses before enrolling in the regular engineering courses. For those needing refresher work the university has established a special summer sessions of eight weeks to remove any weaknesses or lack of entrance requirements. Introduced in five communities this year, the testing program will be extended in the future.

Another suggestion to ease the engineering shortage is that women who are mechanically minded or technically trained be utilized in engineering positions. Acccording to J. J. Thompson, manager of personnel and training at Worthington Corp., "a strong upward curve in research and development activities . . . will in turn create more of a demand in design, product, and application engineering. This will necessitate calling up reserves in the form of latent technical abilities, whether they be within men or women; and women will have the opportunity to compete with men for key engineering positions." In any case, technically trained help can be of great value to a graduate engineer. As reported previously (March, Page 219), the working effectiveness of an engineer can be increased 10 to 15 per cent by the assistance of dependable technicians.

Buzz Bomb Makes Good As Heater

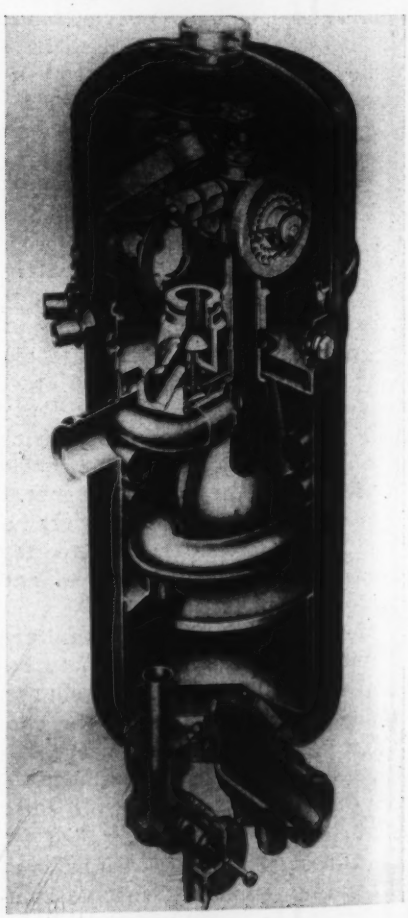
The pulse-jet principle has been applied in three devices labeled Swingheater, Swingfog and Swingburner. The combustion system of these devices operates in the same manner as the pulse-jet engine of the German V-1 buzz bomb. Initially the fuel-air mixture is ignited by a glow-plug; once started, alternate pressure fluctuations serve to induct more of the combustible mixture and compress it to the point where ignition occurs. The combustion cycle repeats 80 times per second. Conversion of fuel to heat is claimed to be from 92 to 95 per cent efficient.

The Swingheater is designed specifically for preheating the coolant in internal combustion engines. An integral tank containing the coiled exhaust pipe has inlet and outlet pipes for connection into the cooling system. Swingfog has a 5-foot straight exhaust pipe and an insecticide or fumigant tank. Velocity of the exhaust gases is used to atomize and spray the insecticide or fumigant as a highly toxic fog. Filling the tank with gasoline converts Swingfog into a very effective flame thrower.

The Swingburner is designed for space heating and can be easily installed in any conventional firebox. A portion of the pressure developed in the combustion chamber is used to force gasoline from a tank to a secondary combustion chamber where it is ignited by the hot exhaust gases. Output is adjustable from 24,000 to 120,000 Btu per hour.

Only one moving part, the air intake or flutter valve, is employed. Made of plastic, the valve is easily

Simplicity of design is characteristic of Swingheater pulse-jet heating unit



IN FOR A LIFE OF HARD LABOR

Shown here are several types of Bethlehem rolled-and-forged circular blanks which are, as you can see, very sturdy specimens. They will be used in different kinds of work, but one and all, they are in for a life of hard labor.

These blanks, and all similar blanks made by Bethlehem, are strong and homogeneous—strong, tough steel from rim to rim. You'll find them perfect for gears, crane wheels, sheave wheels, turbine rotors, flywheels, and other rugged parts that work day in, day out under very heavy loads.

A special process involving both rolling and forging produces uniform density of metal and an excellent grain flow. As a result, something more than strength is achieved. Because of the firm, solid steel all the way through, the blanks machine dependably and easily, with no hidden trouble down beneath. No flaws that can mean discarding a piece after expensive preliminary cuts have been taken.

And speaking of machining: we furnish the blanks rough-machined, so that there's a minimum of finishing work for you, the customer.

Bethlehem circular blanks are available untreated or heat-treated, in sizes ranging from approximately 10 to 42 in. OD. Ask for particulars—or write for a free copy of illustrated Booklet 216.

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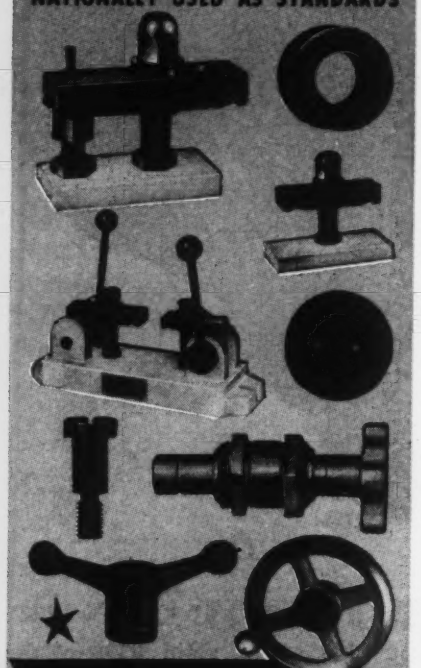
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Engineering News

replaceable, if necessary. Maintenance of the units is said to be negligible and no lubrication is required.

This line of novel heating devices bears the general label of Swingfire, which is a literal translation of *Schwingfeur,* the name which the German developers used to describe its pulsating action. Exclusive rights to manufacture, sell and distribute the line in North and Central America are held by Devenco Inc., New York.

Advisory Group Formed For Materials Conference

Twenty industrial research engineers and government scientists comprise the advisory committee to formulate a program for the first Basic Materials Conference, which will be held next month in New York concurrently with the first Exposition of Basic Materials for Industry.

The conference will present the theme that a knowledge of all materials is essential before a single material can be used for a product. According to the committee, a product engineer can no longer be a specialist in only metals, plastics, lumber or ceramics, but must know the possibilities of each so that he may substitute when shortages occur and also design products for new uses.

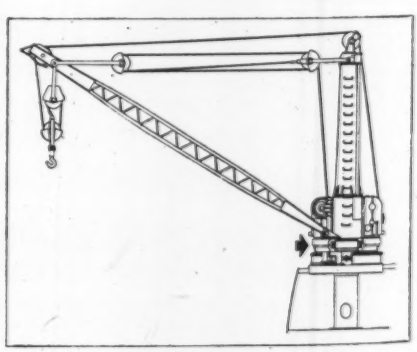
Dates of the conference, which will be held at the Hotel Roosevelt, are June 16-18; the Exposition will be held at Grand Central Palace, June 15-19.

Crane Supported by Spherical Roller Bearing

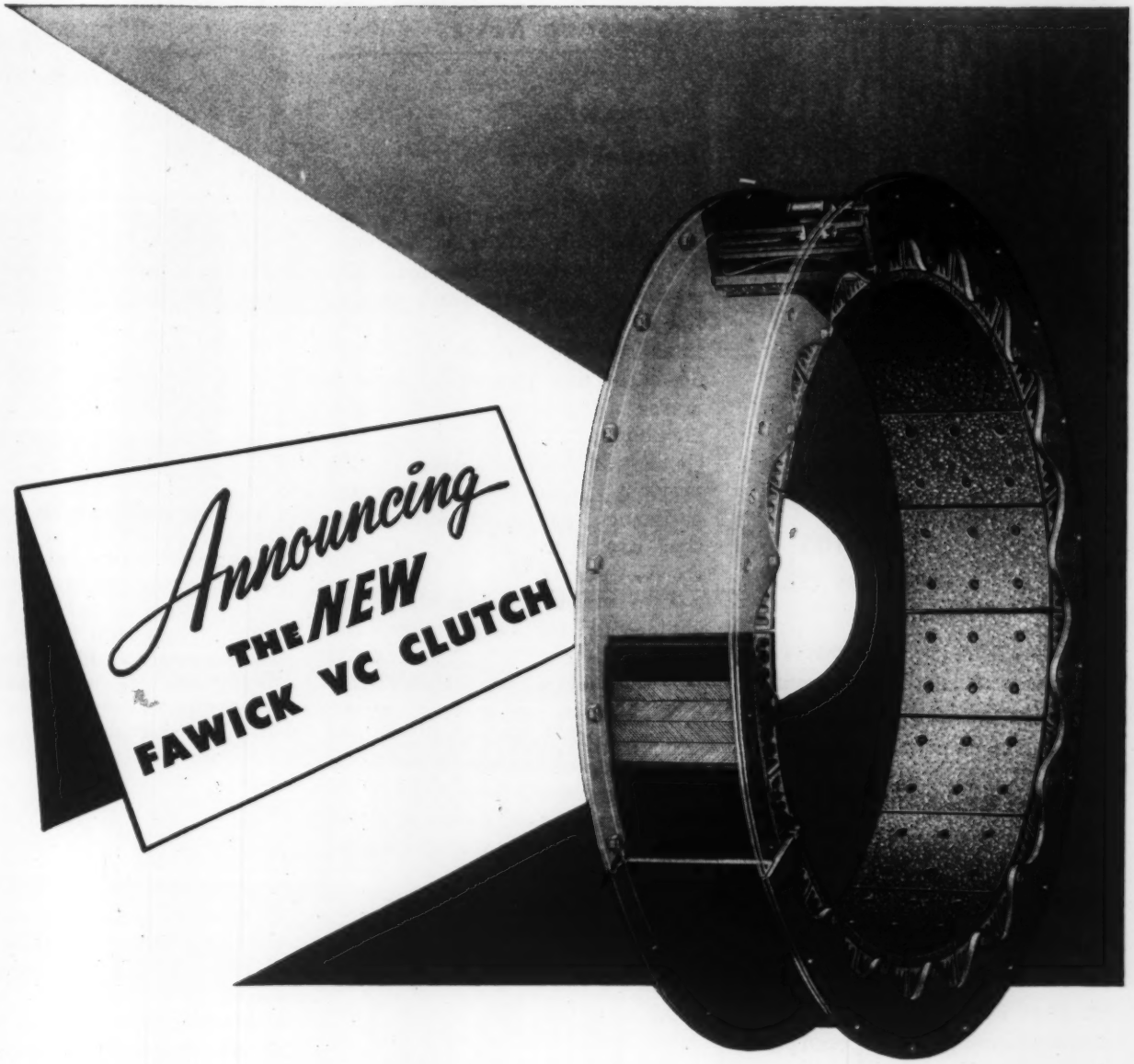
Two special cranes for lifting helicopters and small boats inboard or over the side of the Canadian icebreaker *HMCS Labrador* will be able to handle loads of 7000 pounds at 75 feet per minute or 25,000 pounds at 25 feet per minute. The cranes, built by Western Gear Works, stand 25 feet above deck level and swing 40-foot booms. Most of each crane, including two motors and winches to handle the lines, is mounted on a rotating platform which rides above a stationary platform at deck level. The *Labrador* is expected to be finished

and take her place in the Canadian Navy very shortly.

Supporting the rotating platform and mounted on the kingpost is a Torrington spherical roller bearing 46.4566 inches in diameter. A spherical roller bearing was selected for this application because of its ability to rotate freely despite some misalignment. A heavy load could cause binding, excessive friction and possibly stop rotation altogether, if it were not for the self-aligning feature of this type of bearing. A bearing of this unusual size was needed to fit the kingpost which was designed with a large diameter to meet lifting strains. Loading conditions were not a prime factor in bearing selection since the radial load on the bearing is approximately 62,000 pounds.



Crane for lifting small boats on Canadian icebreaker, showing location of spherical roller bearing



The NEW completely-ventilated
FAWICK TYPE VC *Air-Ring* CLUTCH

FAWICK announces another air-operated clutch advancement. The NEW FAWICK TYPE VC *Air-Ring* CLUTCH is specifically designed and built to fit the needs of manufacturers and users of heavy equipment on the roughest applications.

Design features found only in this NEW VC CLUTCH include:

1. Cooler operation inherent in drum clutch design *plus* isolation of the operating tube from the heat-generating friction surface.
2. Riveted, Replaceable Friction Lining.
3. Loose, Expanding Operating Tube which can be replaced without removing clutch from shaft.

The FAWICK Rigid-Type VC CLUTCH is unmatched for heavy-duty service with high-starting loads and sustained slippage where generated operating heat lowers clutch efficiency and shortens operating life. With its cooler operation the FAWICK VC provides "new clutch" performance throughout a long maintenance-free life.

For further information on the NEW FAWICK VC CLUTCH write to the main office, Cleveland, Ohio, for Bulletin ML-102.

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Engineering News

Cleaning with Ultrasonic Waves

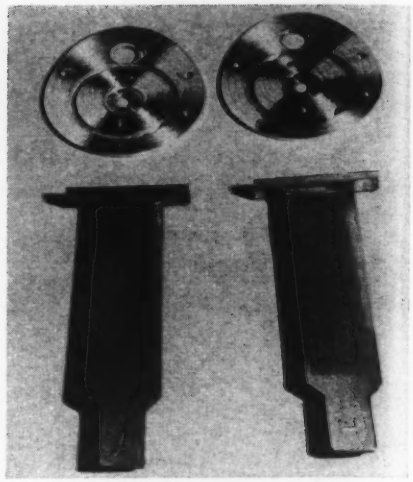
Cleaning metal through the use of ultrasonic waves is accomplished by means of a man-made element for directing sound energy. According to Detrex Corp., where this Soniclean process was developed, the new transducer element makes ultrasonic cleaning a production reality. Use of the new element, in place of quartz crystals previously used in ultrasonic experiments, has overcome limitations caused by the size and properties of quartz.

The transducer element, jointly engineered by Detrex and the Brush Electronic Co., is a curved piece of ceramic resembling a 6-inch-long pipe, cut in half along the longitudinal axis. The ceramic pieces can be connected in series and arranged as desired, and thus are designed to offer ease of focusing and flexibility not found in previous equipment.

Electrical energy is transmitted to the ceramic transducer, converted into sound energy and projected through a solvent at a frequency of 430,000 cycles per second. Because a potential of only 40 volts is required to operate the ceramic transducers, they can be safely immersed directly in the solvent.

Material to be cleaned is placed in the solvent, either manually or by conveyor, directly in the path of greatest focal intensity of the ultrasonic waves. In this area an extreme turbulence is created, resulting in a deep and penetrating cleaning action that removes dirt, grease, chips and microscopic particles of soil from intricate and close-fitting parts.

Design of the ceramic transducer causes sound waves to converge to a straight line as long as the transducer itself. The focal area in other transducers, however, is confined to a single point, which limits ultrasonic cleaning almost to one piece at a time.



Metal parts before and after degreasing by ultrasonic waves. The fishing-reel brass end-plate at the left has a film of brass dust on its surface and in its crevices. Ultrasonic energy cleans such parts almost instantaneously. At the bottom of the photograph are jet engine blades before and after removal of iron oxide paste

Iron oxide paste, used to coat jet engine blades in the detection of possible flaws, is extremely difficult to remove by ordinary methods, but is "exploded" away by ultrasonic waves

New Synthetic Outwears Natural Rubber

Called an entirely new type of synthetic material, Goodyear's polyester rubber, Chemigum S. L., has proved to be longer wearing, tougher and more resistant to abrasion than existing rubbers used for tire treads, according to recent company tests. In laboratory and road tests using alternate sections of polyester and natural rubber treads, the polyester tread showed little

wear after 11,000 miles, while the natural rubber section had worn sufficiently to cause extreme bumping of the tire. In another test, a hydraulic press throw-pad of polyester rubber gave three times the wear of a similar pad made of natural rubber. Chemigum S. L. also displayed great ability to withstand heat and rough tearing forces.

Chemically similar to the German Vulcollan rubber, Chemigum S. L. offers processing advantages. While the German material must be molded immediately, the new polyester provides a reaction factor which makes possible delayed processing on conventional rubber machinery. This factor stops the solidifying reaction of the two chemicals at a point where the resultant material can be further processed on mills, calenders, extruders and other factory equipment.

Possible applications of the new rubber are seen in the field of truck tire recapping and for coatings for rubber and plastics to protect fast-wearing portions of such articles as belt surfaces and flooring.

◆

TV AT WORK: This employee of the Ford Motor Co. Buffalo stamping plant watches television and, by operating remote control buttons and levers, produces the picture appearing on the screen. The "show" consists of bales of scrap being loaded into freight cars outside the plant. Automatic machinery bales and loads the scrap and also controls the position of the freight cars

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FOR SUPER SPEED, THIN GAUGE SITUATIONS
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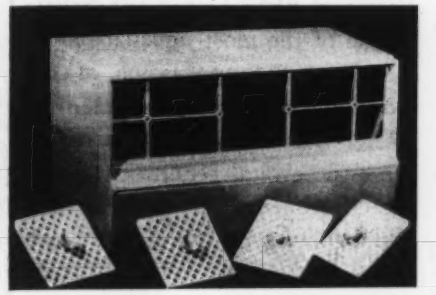
Engineering News

Zirconium Will be Fabricated in Quantity

Fabrication of zirconium (see MACHINE DESIGN, April 1953, Page 324), has progressed to such a point that industry is now forming, rolling and machining parts from ingots a foot in diameter and weighing as much as 500 pounds, according to Dr. R. B. Gordon and W. J. Hurford of the Westinghouse Atomic Power Div., Pittsburgh. Quantity production of zirconium parts on a full commercial scale should occur this year, they predict.

The first commercial-size ingots of zirconium, which is ranked second in importance to uranium for construction of nuclear reactors such as the one being built by Westinghouse for the first atomic submarine, were produced by the Bureau of Mines in 1952. Experimental fabrication started in the same year and has rapidly advanced to a point where quantity production is possible.

AREA ILLUMINATION: Lighting intensity averaging 100 foot candles is maintained in the new engineering department of Van Huffel Tube Corp. by the use of area illumination, which provides even illumination with a minimum of shadows and glare. The installation by Smithcraft Lighting Div. consists of twelve 6 by 12-foot units. Lamps are on 12-inch centers, and 3 by 2-foot white metal egg-crate louvers provide a shielding of 45 degrees crosswise and lengthwise



AIR CONDITIONER CABINET: Injection molded for Servel by General Electric's plastics department, this cabinet is believed to be the first produced by injection molding for room air conditioners. The cabinet is 26 inches wide, 15 inches deep, 14 inches high and weighs 6½ pounds

Aluminum Sets Record In Corrosion Study

Results of a twenty-year corrosion study on aluminum reveal that the metal has achieved a new record in withstanding atmospheric weathering and corrosion. Research findings covered service installations of aluminum that had been exposed to the atmosphere as long as 52 years; controlled test specimens were exposed at weathering stations for as long as 20 years.

Two papers presented by Aluminum Co. of America scientists before the National Association of Corrosion Engineers showed that aluminum alloys are highly resistant to atmospheric weathering. After an exposure period of one or two years, maximum rate of corrosion penetration is less than 0.2-mil per year for the more adverse conditions and less than 0.1-mil per year for normal atmospheric weathering conditions.

Catalytic Muffler Removes Gasoline Engine Fumes

Harmful carbon monoxide and hydrocarbon fumes are removed from gasoline engines by a recently announced catalytic exhaust system, permitting safe operation of fork-lift trucks in confined plant areas. The Oxy-Catalyst Inc. system also prevents contamination of foodstuffs and other perishables

(*Continued on Page* 256)

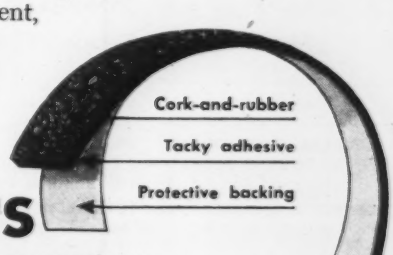
This cork-and-rubber tape stops shocks as well as leaks

Used as a die-cut gasket between the glass face and cast metal housing of parking meters, Armstrong's DK-153 Tape keeps rain and dust out—and prevents glass breakage.

DK-153 is a resilient cork-and-rubber material with a pressure-sensitive adhesive backing that makes it easy to apply. All you do is peel off the cloth backing and press the tape into place. It sticks instantly to any clean, dry surface.

This versatile tape is widely used to cushion breakable parts in shipping. It also makes an ideal anti-squeak and anti-skid material.

DK-153 Tape comes in a variety of widths and thicknesses in sheets, rolls, or die-cut shapes. For samples, write on your letterhead to Armstrong Cork Company, Gaskets and Packings Department, 8505 Arch Street, Lancaster, Penna. Available for export.



ARMSTRONG'S DK-153 TAPE

LORD MOUNTINGS...

Control Vibration in PORTER-CABLE'S 106 PORTABLE SANDER

The unique Lord application illustrated above accommodates controlled orbital motion of the sanding head in the Porter-Cable #106 Finishing Sander. "Lord Bonded-Rubber Mountings", Porter-Cable reports, "outlast any mountings previously used because of the excellent bond between rubber and metal" and thus contribute much to the efficient operation of this popular Porter-Cable unit. You may have a similar problem to solve in the products you manufacture. Your request for information is invited. We will be pleased to consult with you on the application to your products of Lord Vibration and Shock Control Mountings and Bonded-Rubber parts.

BURBANK, CALIFORNIA	DALLAS, TEXAS	PHILADELPHIA 7, PENNSYLVANIA	DAYTON 2, OHIO
233 South Third Street	413 Fidelity Union Life Building	725 Widener Building	410 West First Street
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LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER — *Headquarters for* **VIBRATION CONTROL**

Advertisement

Lord Mountings Perform Unique Fuction On Porter-Cable Portable Sander

One of the most unusual requirements for the application of Lord Bonded-Rubber parts is that of the Porter-Cable Portable Sander 106. Here the orbital action of the sanding component must be held within certain limits by the use of flexible rubber mountings fixed to the four corners of the upper housing and the sanding component. High speed operation is necessary for achieving the desired smoothness of surface on materials to be sanded.

Previously used mountings worked well for a time and then failed. The problem of longevity was put up to Lord Headquarters for Vibration Control in Erie, Pa.

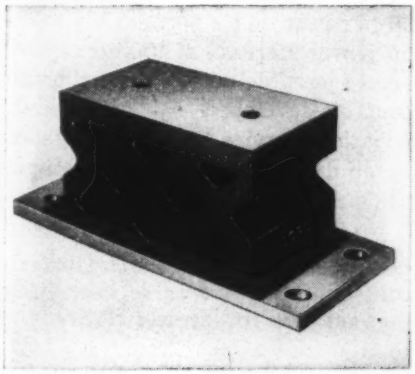
Analysis of the problem showed that the correct rubber compound bonded to threaded metal studs would offer the desired flexibility with reasonable possibility of longer service life and subsequently less failures. Many tests were completed before adopting the mounting shown in the accompanying advertisement. All objections to the operation of previous mountings were removed by this consultation with Lord Engineers and the results of their efforts. This is but another of many such typical solutions of the vibration problems of appliance manufacturers. These problem solutions include correct mounting of spin dryers on automatic washing machines, isolation of transmitted vibration through fan hubs of room air conditioners, the mounting of mixing and blending equipment used by the modern housewife—in fact, wherever vibration and shock present an obstacle to satisfactory machine operation Lord Vibration Control Mountings are being engineered for the job. The experience of more than a quarter century in dealing with vibration and shock problems is available to you in the solution of vibration problems. Your efforts to improve the operation of your product by controlling or isolating vibration will be more effective when you consult with Lord Manufacturing Company, Erie, Pa.

Advertisement

New Lord Lattice Mounting Used To Advantage On Heavy Industrial Machines

The Lord lattice mounting incorporates many features of value to designers of heavy industrial equipment. These mounts are now being used for support of Foundromatic Shakeouts and Aero-Vibe Screens manufactured by Allis Chalmers. Other applications include reciprocating or rotating machinery requiring a high degree of vibration isolation. The load range for a lattice type mounting is 250-2000 pounds per mounting point.

The lattice design of the rubber section permits the load to be carried by the rubber in shear . . . the softest practical type of support. Lattice type mountings offer more stability in the horizontal plane. No lubrication is required thus lowering maintenance costs. Since there are no steel surfaces in contact, quieter operation is possible. The rubber section also offers greater isolation of noise that is easily transmitted through steel springs. The inherent damping of the rubber reduces the excursion of screen in passing through resonance on starting and stopping. No mechanical dampers are required.



The lattice type mounting offers excellent vibration isolation for the lower range of disturbing frequencies. For very low operating speeds, the mountings may be installed in series. The lattice type mounting also accommodates large amplitudes of motion.

The lattice design is another instance where Lord experience in vibration and shock problems has proved valuable to manufacturers. Consult with Lord engineers early in the design phase of your products. Lord's vast reservoir of experience is yours for the asking.

Lord Bonded-Rubber Lattice Mounting supports shakeout equipment, isolates vibration of screen providing protection for motor and drive assembly.

Lord Bonded-Rubber Lattice Mounts are used for support of Foundromatic Shakeouts and Aero-Vibe Screens manufactured by Allis-Chalmers. The lattice design permits the load to be carried by the rubber in shear—the softest practical type of rubber support. Installed under the machine, the lattice mounting eliminates the overhead supporting structure necessary with the overhead coil spring suspension system.

This is another illustration of how Lord Bonded-Rubber parts are being used profitably in many industries. Consult with Lord engineers on your vibration or shock problems. We invite your inquiry.

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LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Headquarters for
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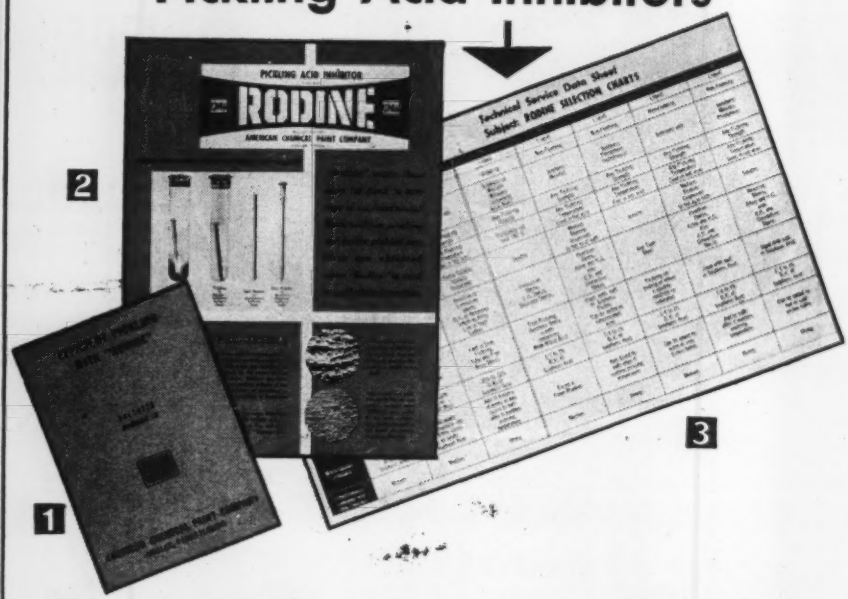
New Data Available on . . .

RODINE®

Pickling Acid Inhibitors



1 The standard reference work on pickling, "Efficient Pickling With RODINE" — Bulletin Number 13 — is now available in a new, revised edition.

2 This new 4-page general descriptive folder presents essential information on "Rodine" pickling acid inhibitors.

3 The recently revised "RODINE SELECTION CHART" gives characteristics of and uses for typical "Rodines" used with sulfuric and muriatic acids. Technical Service Data Sheet No. 13-1-1-4.

Use coupon below for free copies of the literature described above.

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Engineering News

(*Continued from Page* 253)

that might be tainted by exhaust.

Basic unit of the muffler is the Oxycat, a cartridge of spaced porcelain rods coated with catalytic alumina and platinum alloy. The engine exhaust flows across the surface of these rods, where combustion of carbon monoxide and other harmful vapors takes place. On leaving the catalyst, the exhaust contains mostly carbon dioxide and water vapor.

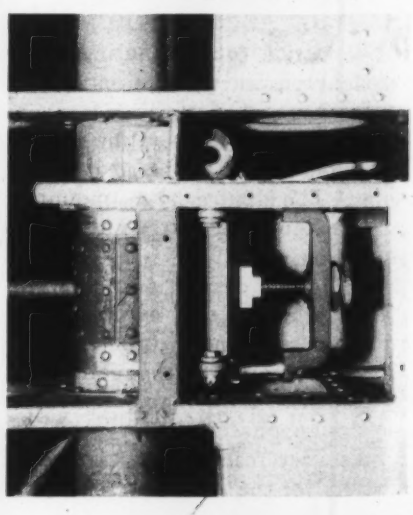
Mufflers contain two, three or more individual cartridges, depending on the size of the truck engine and, in most cases, attach to the engine manifold, replacing the regular muffler.

The Oxycat has been used in combatting air pollution and recovering waste heat energy in industrial plant installations. In use at a metal finishing plant, the system oxidized noxious solvent fumes into heat energy that could be used to run the plant's coating lines.

Trim Tab Control Increases Aircraft Efficiency

Rudder-pedal force reduction of 50 per cent and a permissible take-off power increase of 150 horsepower are possible with a new trim tab control developed by AiResearch Aviation Service Co., Los Angeles. Safer flying and less pilot fatigue are claimed to result from installa-

Newly designed AiResearch trim tab control. Drum and cable have been omitted for greater clarity



Why Stemm Brothers' designers use Morse Roller Chains on their Hi-Tender

The Hi-Tender, manufactured by Stemm Brothers, Inc., is a simple, reliable, highly flexible machine that helps workmen do hours of overhead work in minutes.

For instance, it will quickly raise or lower an eight-hundred-pound load 33′ vertically or spot it 22′ away horizontally (maximum distances greater or smaller on order). It's a safe, economical, efficient tool for farmers, sign painters, street-light maintenance crews and others who need mobile high-lift equipment.

Hi-Tender performs its lifting and lowering functions through a system of hydraulic pumps, Morse Roller Chains and Sprockets, and steel cables.

Bonus performance

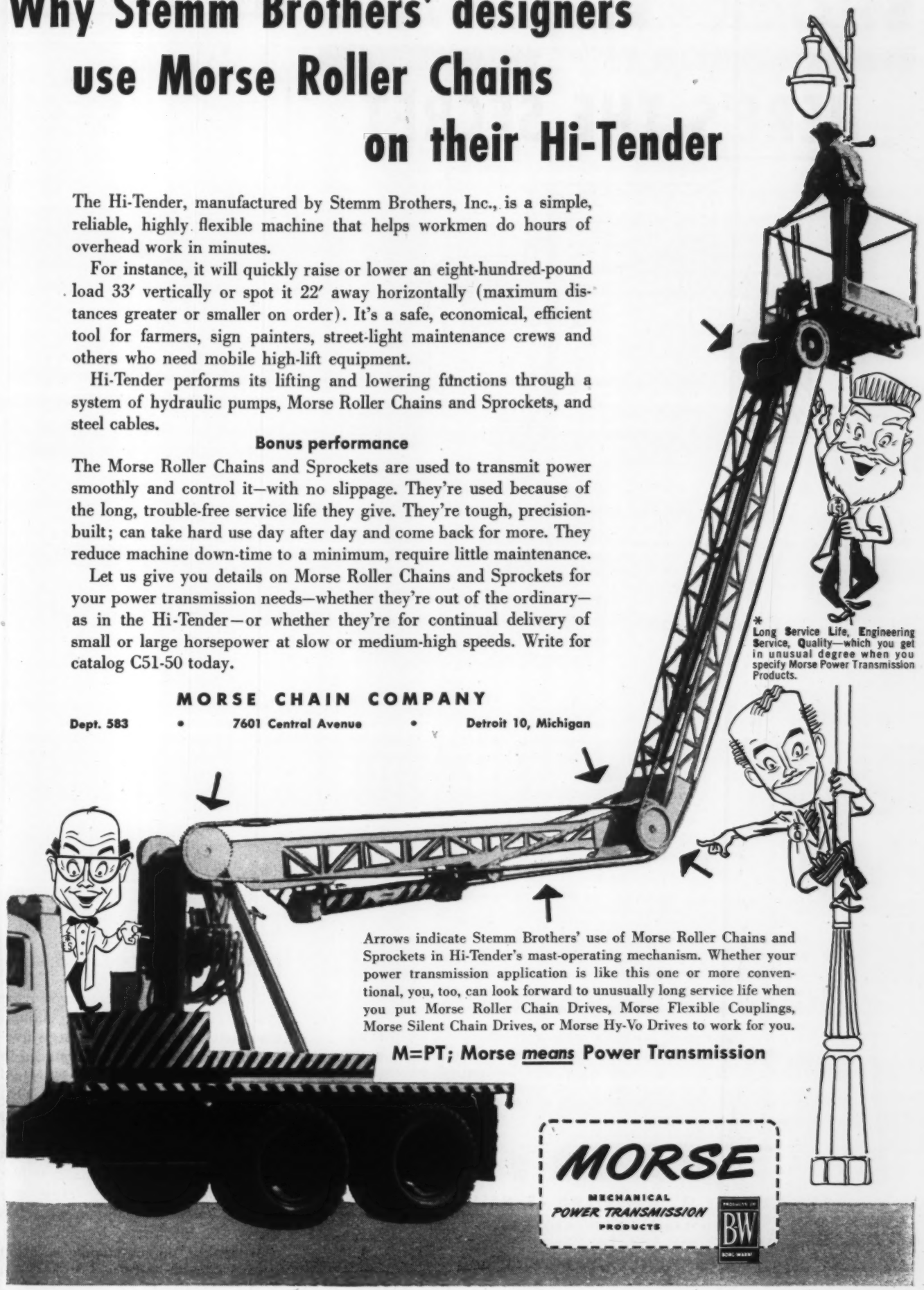
The Morse Roller Chains and Sprockets are used to transmit power smoothly and control it—with no slippage. They're used because of the long, trouble-free service life they give. They're tough, precision-built; can take hard use day after day and come back for more. They reduce machine down-time to a minimum, require little maintenance.

Let us give you details on Morse Roller Chains and Sprockets for your power transmission needs—whether they're out of the ordinary—as in the Hi-Tender—or whether they're for continual delivery of small or large horsepower at slow or medium-high speeds. Write for catalog C51-50 today.

MORSE CHAIN COMPANY

Dept. 583 • 7601 Central Avenue • Detroit 10, Michigan

* Long Service Life, Engineering Service, Quality—which you get in unusual degree when you specify Morse Power Transmission Products.



Arrows indicate Stemm Brothers' use of Morse Roller Chains and Sprockets in Hi-Tender's mast-operating mechanism. Whether your power transmission application is like this one or more conventional, you, too, can look forward to unusually long service life when you put Morse Roller Chain Drives, Morse Flexible Couplings, Morse Silent Chain Drives, or Morse Hy-Vo Drives to work for you.

M=PT; Morse *means* Power Transmission

MORSE

MECHANICAL *POWER TRANSMISSION* PRODUCTS

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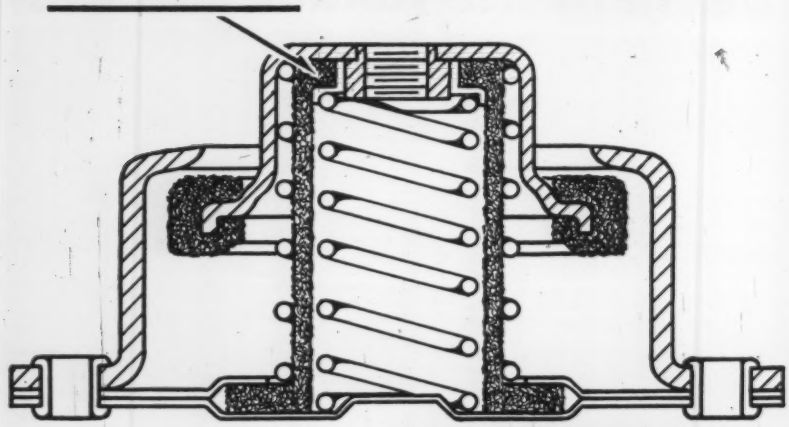
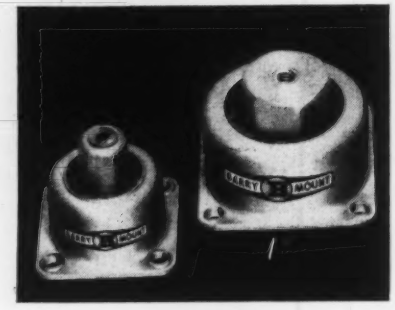
SHOCK AND VIBRATION NEWS

HERE'S THE SECRET



. . . of a NEW wire-mesh isolator that won't change on the job!



The new Type 7630 and Type 7640 ALL-METL Barrymounts have been specifically designed to eliminate loss of efficiency due to damper packing. Previous wire-mesh unit vibration isolators exhibited a definite loss of damping efficiency after a period in actual service, because the wire-mesh damper tended to pack. These new unit Barrymounts have eliminated this difficulty, because load-bearing spring returns damper to normal position on every cycle.

- Very light weight — helps you reduce the weight of mounted equipment.
- Hex top — simplifies your installation problems.
- High isolation efficiency — meets latest government specifications (JAN-C-172A, etc.) — gives your equipment maximum protection.
- Ruggedized — to meet the shock-test requirements of military specifications.
- Operates over a wide range of temperatures — ideal for guided-missile or jet installations.

Compare these unit isolators with any others — by making your own tests, or on the basis of full details contained in Barry Product Bulletin 531. Your free copy will be mailed on request.

Free samples for your prototypes are available through your nearest Barry representative.

THE **BARRY** CORP.

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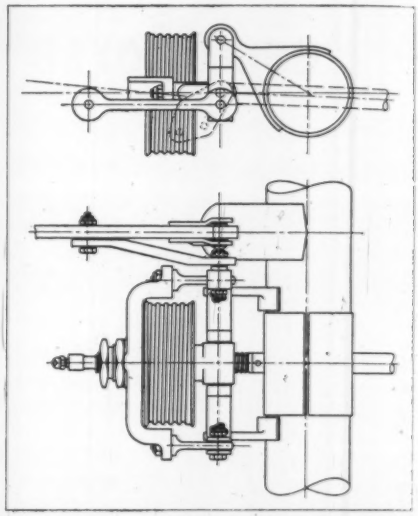
Engineering News



Top and side views of trim tab control with cable drum installed

tion of the device, which has been approved by the Civil Aeronautics Administration for use on DC-3 aircraft.

Rudder travel is limited to 20 degrees, preventing the rudder from reaching the stall zone. Thus, full control of the airplane at all times, including takeoff, is possible. The system is the only one approved for use with an electronic autopilot.

Actuation is through a conventional control cable which rotates a drum and screw. The screw moves an actuator arm in a direction corresponding to control movement. This movement is then transmitted by a link and pushrod to the trim tab.

Atom Power Plant Placed in Operation

A homogeneous nuclear reactor system capable of producing enough electricity to heat 50 average five-room houses was recently placed in operation at Oak Ridge National Laboratory, Oak Ridge, Tenn. This is the first reactor of this type to operate at high enough temperature and power to produce steam for operation of a standard industrial turbine-generator. Heat output of the turbine-generator is about 150 kilowatts.

A single homogeneous solution serves as fuel, moderator and cool-

Restores worn car wheels automatically

. . . with help of TIMKEN® bearings

THIS Niles 52″ car wheel lathe, manufactured by Baldwin-Lima-Hamilton Corporation, roughs and finishes worn car wheels automatically—all in one operation! A hydraulic stylus follows a predetermined contour of the profile. Special micrometers and calipers measure and gage the wheels to determine the amount of material to be removed in re-profiling the wheel contours.

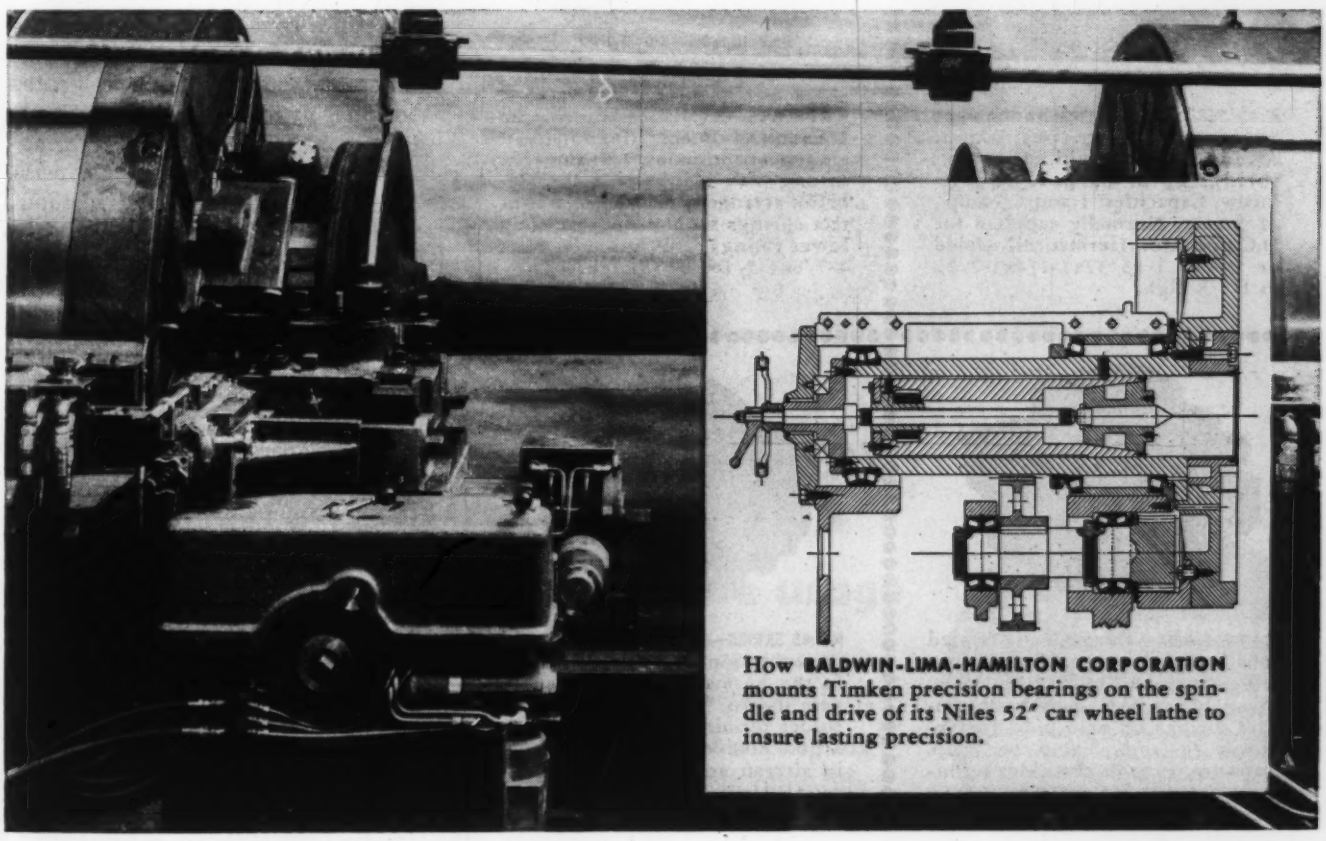
To maintain the high precision necessary, Niles mounts the lathe spindle on Timken® tapered roller bearings. Because of line contact between their rollers and races, Timken precision bearings have extra load-carrying capacity. Their tapered construction takes both radial and thrust loads, permits pre-loading to any desired degree. Result: deflection is minimized, long-lasting accuracy is assured.

To help turn the heavy load of the wheels and axles smoothly, Timken bearings are also used in the drive. They hold shafts in alignment, insuring accurate gear mesh, longer gear life.

Timken bearings are easy and less costly to assemble. Manufacturing costs are reduced. Auxiliary thrust bearings are eliminated, maintenance is simplified.

No other bearing can give you all the advantages of Timken bearings. Make sure you have them in the machine tools you build or buy. Always look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How **BALDWIN-LIMA-HAMILTON CORPORATION** mounts Timken precision bearings on the spindle and drive of its Niles 52″ car wheel lathe to insure lasting precision.

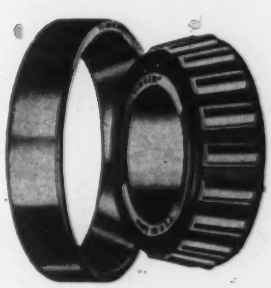
MAGNIFYING GLASS INSPECTION OF EVERY ROLLER!

Every one of the over one billion Timken bearing rollers produced every year is inspected with powerful magnifying glasses to detect surface flaws. It's just one example of how the Timken Company insures uniform high quality.

TIMKEN

TRADE-MARK REG. U.S. PAT. OFF.

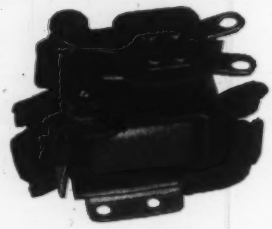
TAPERED ROLLER BEARINGS



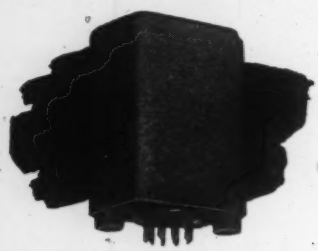
NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ↓ AND THRUST → LOADS OR ANY COMBINATION ↔

Outstanding because they are built to Excell the 'Specs'

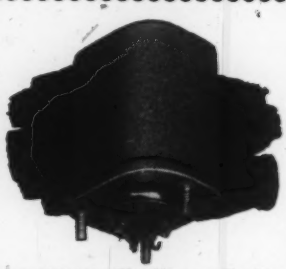
R 45 SERIES—Small telephone type relay with pin hinge construction. Available with multiple contact springs up to six pole double-throw. Capacities: 1 amp., 3 amp., or 5 amp. Normally supplied for D.C. operation. Hermetically sealed or open. 1-13/32x1-1/4x1-7/32 to 1-5/8 high.



R 83 SERIES—Available with A.C. or D.C. coils. Contact ratings up to 30 amperes continuous, 150 amperes inrush with single pole double-break arrangement. Multiple contact springs with proportionately lower ratings also available. Size: 1-7/8x1-5/16x1-5/8 high.



R 94 SERIES—Hermetically sealed small telephone type relay with pin hinge construction for long life. Available in D.C. only with contact springs up to 4 pole double-throw. In 1 amp., 3 amp., or 5 amp. capacity. Plug-in or solder terminals. Overall size 1-5/8 x 1-1/32 x 2-1/4 D.



RB 45 SERIES—Similar to R 45 with the exception that it is designed to fit the hermetically sealed enclosure shown. Three stud mounting; solder terminals. Available up to 4 pole double-throw. Widely used in aircraft and ground communication equipment. Size: 1-5/8 x 1-7/16x2-1/32 D.

"Diamond Quality" TIME SWITCHES...

Automatic Electric also produces a complete line of Time Switches and Timers, both manual and automatic reset. Write for information.

AEMCO

Automatic Electric MFG. CO.

64 STATE STREET MANKATO, MINN.

Engineering News

ant. Heat generated by nuclear reaction of uranium fuel in the solution is removed by pumping the hot radioactive liquid through a heat exchanger or boiler which produces steam to drive the turbine.

Cost of construction and fabrication of the reactor including auxiliaries, building and site was $1.1 million. Research and development costs were approximately $3 million.

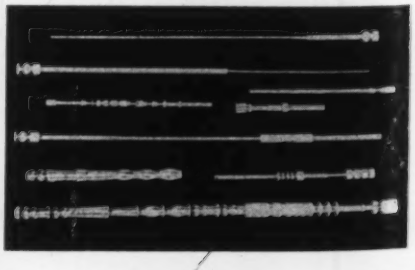
New Heating Technique For Large Aluminum Ingots

Ordinary household electric power can heat a 7700-pound aluminum ingot to working temperature nearly 15 times faster than it could be done in a conventional furnace, according to D. I. Bohn of Alcoa. In a recent test, an ingot was heated to 750 F by 60-cycle induction heating in 50 minutes, whereas bringing it to proper working temperature by conventional methods would require about 12 hours.

A newly developed low-cycle induction heating method compares favorably with installation and operating costs of conventional equipment, and permits use of smaller equipment. The method can be used in operation of big forging and extrusion equipment as well as for annealing and heat treating fabricated products.

♦

FISHING RODS?: Long, slender, straight or tapered valve stems, shafts and similar parts can be made to unusual lengths with a newly developed attachment on the Turnomat turning machine. Bar stock extends through a rotating collet on the attachment, and is driven by the lathe or screw-machine spindle. The collet, movable along the length of the stock, thus "backs up" the cutting tool, permitting high accuracy



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for extra safety in high-pressure usage

Factory assembled to your specifications — you get just what you want — plus an extra margin of safety and dependability.

Exclusive, ductile-sleeve, swaged-on grip makes coupling virtually part of hose reinforcing wire — prevents blow-offs.

No leaks — positive seal eliminates leakage even under extreme pressures.

Cuts assembly costs — neat, compact design makes installation fast and easy — gives you a better-looking job.

Get all the details. Attach coupon to your letterhead and mail today.

NEW!
REVOLUTIONARY
ANCHOR FLANCO
SPLIT-FLANGE CLAMP
Positive leakproof connection without threaded joints. Bolt centers are located to distribute the forces evenly and prevent tilting of the clamp halves. Easy to assemble with small automotive-type wrench.

D-16

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FACTORY BRANCHES: DETROIT, MICHIGAN • DALLAS, TEXAS

Anchor Coupling Co. Inc.
Dept. MD53, Libertyville, Illinois

I'd like to know more about

- ☐ Anchor Ductile-Sleeve Hose Assemblies
- ☐ New Anchor Flanco Split-flange clamp-type coupling

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Name..... Title.....

Company Name.....

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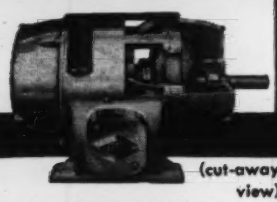
City..... (.....) State.....

DO THESE NEW
Reuland motors

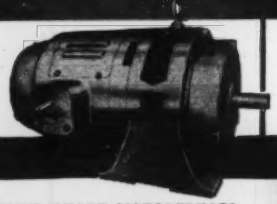
FIT INTO YOUR PICTURE?



(cut-away view)

FLUID-SHAFT MOTOR

Provides smooth acceleration of heavy loads. More compact than separate motor and fluid coupling. *Perfect alignment!* Thousands in use on cranes, mixers, centrifugals, etc.



FLUID-SHAFT MOTOREDUCER

This Fluid-Shaft motor and gear reducer combination converts the motor's conventional high speed into a slow speed, smooth starting, compact unit. Ideal for car pullers, conveyors, dryers, etc.

MAGNETIC BRAKE

The only brake that permits the use of TWO output shafts per motor. *When desired, the motor shaft can be extended right through!* Only 6 major parts...no levers or linkage... self adjusting . . . half usual length!

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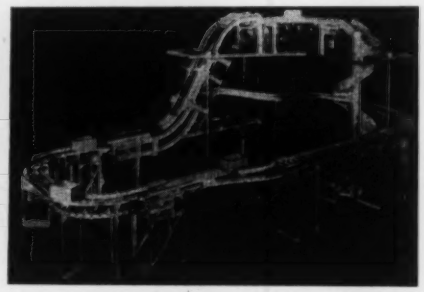
Engineering News



ROLLER COASTER: Resembling a roller coaster, this model conveyor has been developed by Lamson Corp. to demonstrate seven different types of conveyors operating in one unified system. The model will be in operation at the Fifth National Materials Handling Exposition, May 18-22, in Philadelphia

♦

A new engineering organization, the **Leake Engineering Co.**, has entered the metal stamping field. The company will be located in Monroe, Mich., and will operate as an entirely separate unit from the Leake Stamping Co. of Monroe. Services of the organization will include product design, conversion, development and estimating stamping and die costs, die design and consulting. It will also supervise the placement of stampings or dies and their tryout, when desired.

♦

Bruce H. Rasmussen has been named sales manager of **Miller Motor Co.**, Chicago. He previously was associated with J. T. Baker Chemical Co. for 19 years, having served as Chicago branch manager, sales manager of the laboratory chemical division and sales manager of the government contract division.

♦

Hanna Engineering Works, Chicago, has appointed the Barton Sales Co., Fort Wayne, Ind., as representative in northern Indiana, including the cities of Fort Wayne and South Bend.

♦

The Chicago office of **Graton & Knight Co.**, Worcester, Mass., has been moved from 164 North Wacker Dr. to 546 West Washington Blvd., Chicago 6, Ill. Arthur M. Norris continues as district manager.

cold forged
metal fasteners

● For (√) high quality material, (√) precise machining, (√) fast assembly, and (√) good appearance, specify CHANDLER cold forged metal fasteners. They are manufactured from tested high quality alloy steel by the most modern machinery and methods. Every fastener must pass rigid inspection to make sure it meets your specifications. This uniform high quality makes assembly faster, and smoothly finished heads assure good appearance of the completed assemblies.

Specialists in Alloy Bolts . . . Grinding to close tolerances . . . Drilled heads or shanks. Diameters 1/4" 5/16" 3/8" to 3" in length and diameters 7/16" 1/2" 9/16" to 5" in length. 961-CH

Manufacturers of Place Self Locking Bolts

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Bonderite and Bonderlube can help you get economical mass production of metal parts

Key to the new technique of making metal flow is the lubrication system provided by Bonderite and Bonderlube. Bonderite puts a dense, non-metallic phosphate coating over and integral with the metal. Bonderlube reacts with the Bonderite to form an amazingly efficient lubricant that allows greater flow of metal than ever before with higher production, better product, and lower cost.

Bonderite and Bonderlube installations today are helping many manufacturers do "impossible" things by cold extrusion. Applications are in both defense and civilian work.

Take advantage of the proven products, Bonderite and Bonderlube. Take advantage, too, of the exclusive flow of information from Metallgesellschaft, Parker's German affiliate, supplementing the long experience of our technical staff in the application of this new technique. Call us in on your cold extrusion problems.

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Since 1915—leader in the field

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**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U. S. Pat. Off.*

This shaft was extruded from a bar two-thirds its length. Think of the metal, machine time, and labor saved!
This collar produced in one operation from blank shown, treated with Bonderite and Bonderlube.

BONDERITE—corrosion resistant paint base • **BONDERITE and BONDERLUBE**—aids in cold forming of metals
PARCO COMPOUND—rust resistant • **PARCO LUBRITE**—wear resistant for friction surfaces

THESE Industrial Gearmotors are built to stand up under all conditions. Here's why — quality construction throughout, finest alloys for gears and pinions, accurate alignment, heavy-series ball bearings, rigid cast iron frames and precision production.

A. O. Smith Gearmotors are offered in twenty-one standard speeds ranging from 780 RPM down to 13.5 RPM and in ratings from 1 HP to 50 HP. Standard AGMA Classes I, II and III. Special output speeds and mounting arrangements available on request.

FREE— For 12-page engineering bulletin, write A. O. Smith Corporation, Electric Motor Division, 1000 Webster St., Dayton 4, Ohio. Or, Western Division, 5715 SMITHway St., Los Angeles 22, Calif.

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International Division, Milwaukee 1, Wisconsin

Stress Relief

LAST week's mail to J. P. Henderson brought this signed letter which we quote in part. On the chance that revealing the writer's name might prove embarrassing, we'll just call him Joe.

"When evaluating a potential employee which type of experience do you consider most important for a position in a design engineering department? A good design background in the general field in which your product falls with some experience in manufacturing such as tooling, quality control, specification practices, etc? Or would a man with specialized experience in design of your particular product be more valuable?

"In other words, should a young designer try to specialize in a given line of machinery or should he choose a general field and try to broaden his experience at the expense of specialization in certain types of machines within that field?

Here's J. P.'s answer.

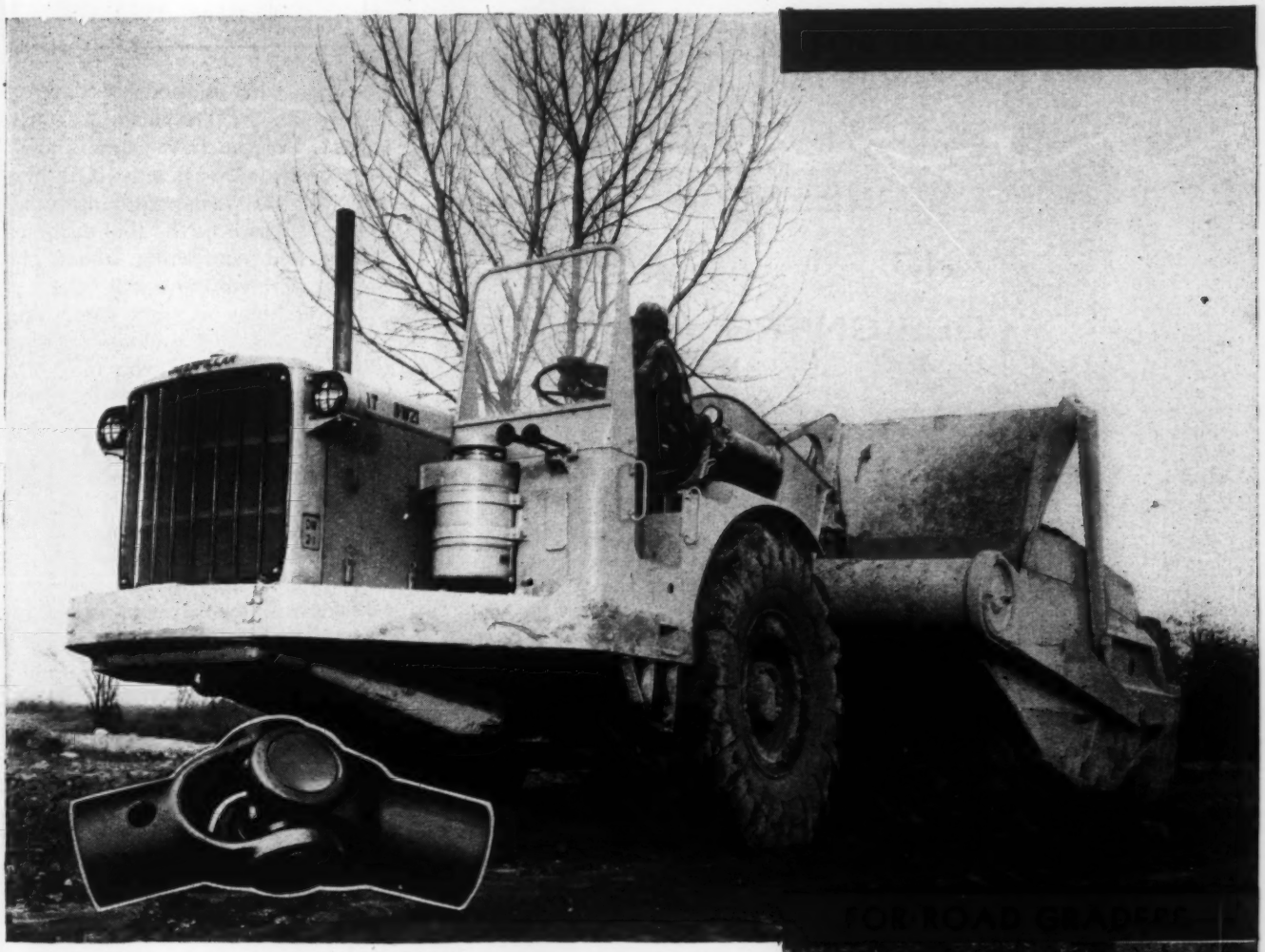
Advice to the Job-Worn

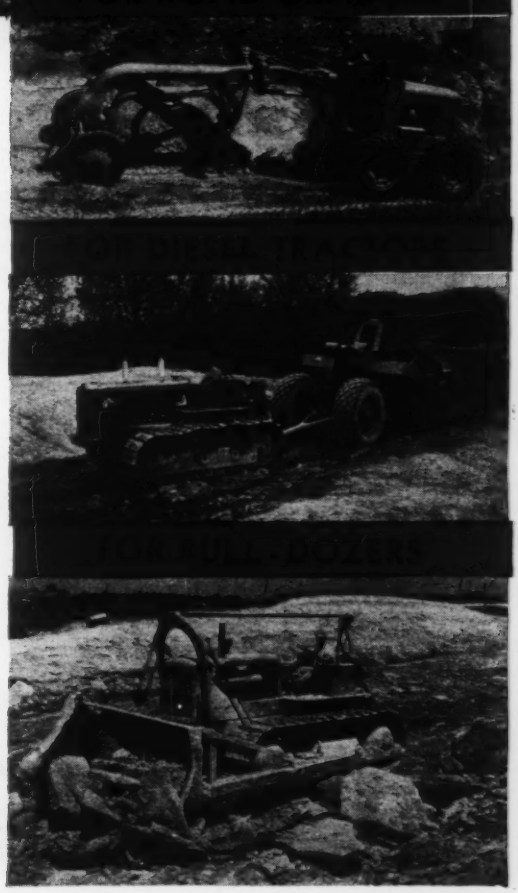
It has long been established that the ancients are garrulous and full of advice. In keeping with this trait and with no effort at all, I can advise this young man on his problems.

However, his inquiry uses terms such as "narrow specialization" and "broad training" which are *relative*. As Voltaire said so wisely, "If you would argue with me you must first define your terms."

Just what do you mean by narrow specialization? Do you mean that you know a great deal about your product, that you can do an excellent job of designing it, and when unusual problems come up you're a fast man with a slide rule and can figure it out as well as get it on a drawing? Let's call that—with no other related knowledge—ultra-narrow.

Or do you know at least something about quality control and





Rugged Construction Work Demands MECHANICS Stamina

There is a size and type MECHANICS Roller Bearing UNIVERSAL JOINT for every construction equipment application. From 200 to 50,000 pounds foot torque — with a wide variety of end fittings and shaft arrangements — for both drive lines and steering columns — MECHANICS JOINTS "measure up" in the toughest service. Let MECHANICS engineers help solve *your* heavy-duty universal joint problems.

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ENGINEERS
AND
DESIGNERS

with experience in

SMALL, PRECISION DEVICES

HUGHES RESEARCH AND DEVELOPMENT LABORATORIES, one of the nation's leading electronics organizations, is now creating a number of new openings for qualified electro-mechanical engineers and designers in important phases of its operations.

HOW TO APPLY

Write today to address below, giving details of qualifications and experience. Assurance is required that any relocation of an applicant will not cause disruption of an urgent military project.

THE COMPANY

The Hughes Laboratories, located in Southern California, are presently engaged in the development and production of advanced radar devices, electronic computers and guided missiles.

THE OPPORTUNITIES

Opportunities are offered for men who will perform interesting work on development of intricate new devices in close association with outstanding scientists. Activities will embrace a variety of challenging problems requiring originality and affording unusual possibilities of progress in learning.

FIELDS OF WORK

The work includes such fields as those involving Servo Mechanisms, Computers, Microwave Tubes, Pulse Circuitry, Solid-State Physics, Miniaturization, Antennas—Waveguides, Heat Transfer, Hydraulics—Gyros, Test Equipment, Subminiaturization, Stress Analysis, Instrumentation, Structures, and Precision Production Mechanisms.

YOUR FUTURE

Working experience in advanced techniques employing the above fields will increase your value to the Company as it further expands in development of electro-mechanical devices. Large-scale use of electronically controlled systems in business and industry is a certainty within the next few years.

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

SCIENTIFIC AND ENGINEERING STAFF
CULVER CITY, LOS ANGELES COUNTY, CALIFORNIA

Stress Relief

manufacturing methods so that you can design with reasonable tolerances? Do you have some knowledge of heat treatment (if it pertains to your work) and materials? Do you know how the tool designer thinks and something about the tooling that your job will take?

If you know at least something about these things and similar ones related to your job, you may still be a specialist but not an ultranarrow one. Personally, I'd take for granted that you should know such things if you had worked for me.

But before we go on to the broader training let's take a backward look at that ultranarrow man. I've known several. Almost everything they did required minor correction. Their sketches and drawings had to be "processed;" their requirements and conclusions had to be modified. In short, someone had to "mop up" after them. They were nuisances in an organization but were tolerated only because they were otherwise so darned smart in their specialty.

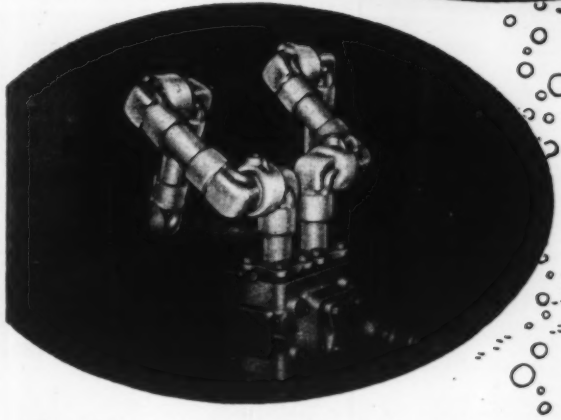
So unless you can qualify as a near genius, Joe, I'd not advise you to attempt fame by too narrow a specialization.

Let's look at the broader field. Suppose you know your line fairly well but are also interested in knowing "less and less about more and more." If those broad interests are paralleled in part by your organization's requirements, you can be looked upon as a very useful man to have around. If those broad interests are of a type which display you as executive timber you might be considered for promotion.

In spite of all these generalities, much really depends upon your local conditions. I've known specialists whose jobs and interests were not duplicated by anyone else in their company. Although they showed executive caliber they were consistently passed up for promotion because no one else knew their work as well and they could not be spared from their present jobs.

Yet in other cases, if there are several men in the same organization with parallel duties, the man

Safety of its people and property, plus increased efficiency and economy of operation, were the chief considerations which turned Johnson Motors to Chiksan Swivel Joints.



Chiksan ball-bearing swivel joints installed on Lester-Phoenix die-casting machine helped Johnson Motors meet its fluid cost problems.

Johnson Motors die-casting department, one of the largest in the Middle West — and the largest captive plant in this country — selected Chiksan hydraulic swivel joints when it converted its machines from flammable oils to nonflammable hydraulic fluids.

Forty-eight package die casting machines are operated on a staggered three shift basis, producing more than 400 aluminum alloy die castings ranging from ½ ounce to 11 pounds in size. Hydraulic systems are operated at pressures up to 2000 psi, with average total die forces in the range of 300 to 500 tons. Castings are made at temperatures between 1100° and 1200° F.

Chiksan ball-bearing swivel joints have helped to reduce fluid losses from 40,000 gallons per year to 10,000 gallons. In contrast to former loss of from 1 to 3 gallons in repositioning bolted lines, Chiksan joints permit resetting of table level with virtually no fluid loss. Time consumed in resetting table levels has been reduced from 2 men and 1 hour to one man and 15 minutes of time.

This story is typical of the many ways thousands of manufacturers are using Chiksan ball-bearing swivel joints for greater safety, efficiency, and economy in their operations.

For Safety, Economy and Efficiency in your die casting department Chiksan has plans and applications worthy of your immediate and serious consideration.

Write CHIKSAN Engineering Research Division today for our NEW Catalog No. 53-C, Dept. MD-5

The Flow of Enterprise Relies on **CHIKSAN**

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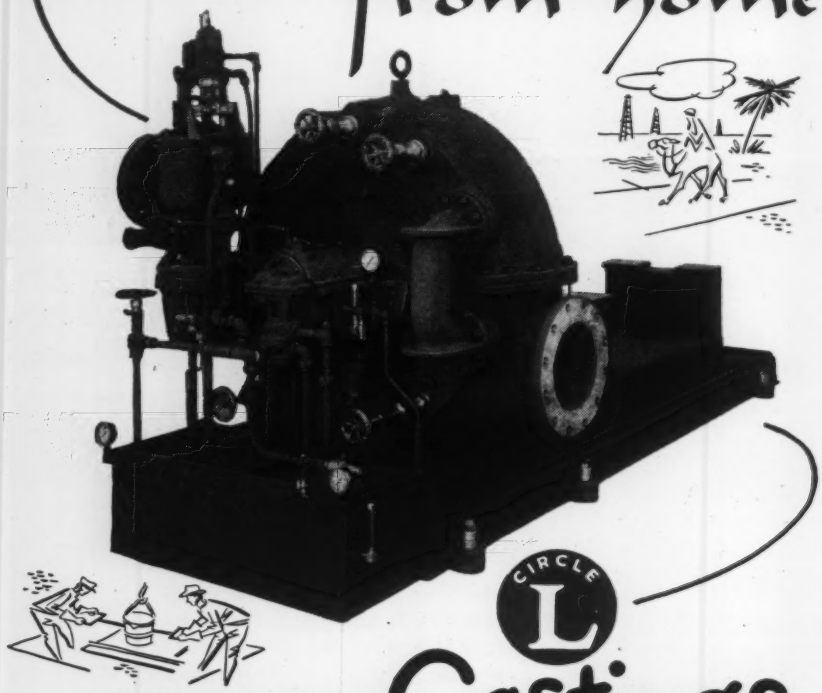
Ball-Bearing Swivel Joints

In turbines 7148 miles from home



CIRCLE L

LEBANON Castings are at work

ON the lonely oil fields of the Saudi Arabian desert nine turbines break the stillness with their steady whine of work. These are Terry Steam Turbine Company's Type C.S. Turbines, and all the castings in these turbines are made by Lebanon Steel Foundry. Driven by waste gas from the oil fields, they power heavy-duty pumps that deliver 100,000 barrels of oil a day.

Operating at 280°F., 450 pounds pressure, the turbines, which are among the largest natural gas turbines in the world, develop a mighty 1940 H.P. at 4400 R.P.M. Terry Steam and their customer, the Arabian-American Oil Company, know that satisfactory service is doubly important when replacement parts are thousands of miles away and repairs are costly. You can be sure that these factors figured prominently in the selection of Circle (L) Steel Castings, products of true craftsmanship.

You should see — STEEL WITH A THOUSAND QUALITIES — A 37-minute 16 mm full color sound film on the making of steel castings. For information write: Dept. G, Lebanon Steel Foundry.

LEBANON Castings

CARBON, SPECIAL ALLOY AND STAINLESS STEEL

CIRCLE L

Stress Relief

of that group who "spreads out" usually stands a better chance of being promoted.

So much for trying to get ahead on your present job, Joe. Let's suppose you want to use your job as a stepping stone to go somewhere else. Here I can only tell you what I would have thought if you had appeared in my bailiwick some years ago.

I'm engaged in manufacturing powered garden tractors (let us suppose) and you have been working for a pump company. You apply to me for a job. I'd try to find out how much you know, not especially about pumps but about design and manufacturing in general. I'd give you consideration but only if I need men badly. I'd think:

Oh bosh, why not wait until a man shows up who has had some experience in our own line. Think of all the special training we'll have to give this man. For a year or so he will be worth much less money to us than he's been making and we probably can't expect him to work for less. Maybe we'd be better off to get a less experienced man for less money and train him. He might have less to unlearn.

With those thoughts in mind I'd not offer you a job at all, Joe, if you had shown up as too much of a specialist; and I'd have to be pretty desperate to offer you one (in spite of looking like a broad caliber man) if your experience didn't parallel our line of work.

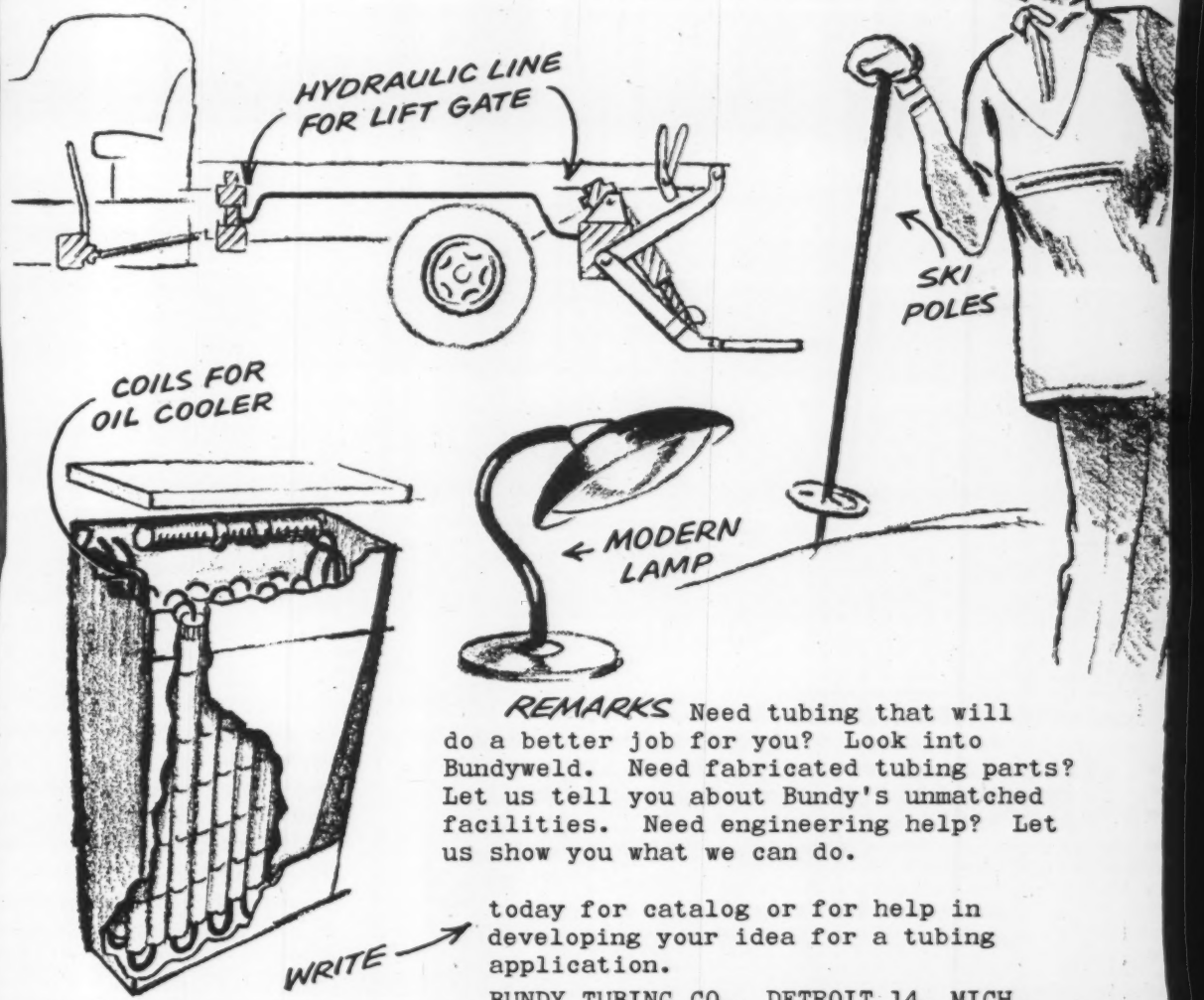
The broad background gives you a better chance, but one lesson you'll learn when you start looking around is that it's very difficult to get from one specialty to another.

If out of all these ifs, ands, and buts, Joe, you can see any basis for decision, you're welcome.

—J. P. HENDERSON

"In the gigantic field of applied science, the trained engineer is now emerging into the executive field. It is said that the heads of more than one-half of the great productive corporations are trained engineers."—HERBERT HOOVER.

FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



REMARKS Need tubing that will do a better job for you? Look into Bundyweld. Need fabricated tubing parts? Let us tell you about Bundy's unmatched facilities. Need engineering help? Let us show you what we can do.

today for catalog or for help in developing your idea for a tubing application.

BUNDY TUBING CO., DETROIT 14, MICH.

Bundyweld Tubing

® DOUBLE-WALLED FROM A SINGLE STRIP

Leakproof
High thermal conductivity
High bursting point
High endurance limit
Extra-strong
Shock-resistant
Ductile

Lightweight
Machines easily
Takes plastic coating
Scale-free
Bright and clean
No inside bead
Uniform I.D., O.D.

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive patented Bundyweld beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

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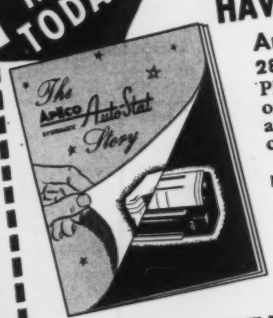

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Meetings

AND EXPOSITIONS

May 18-22—

Materials Handling Exposition: Fifth national exposition to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 20-22—

Society for Experimental Stress Analysis. Spring meeting to be held at Hotel Schroeder, Milwakee, Wis. W. M. Murray, box 168, Cambridge 39, Mass., is secretary-treasurer.

May 24-28—

American Society of Mechanical Engineers. Oil and Gas Power Division Conference to be held at Hotel Schroeder, Milwaukee, Wis. C. E. Davies, 29 West 39th St., New York, N. Y. is secretary.

May 24-28—

Scientific Apparatus Makers Association. Annual meeting to be held at the Greenbrier Hotel, White Sulphur Springs, W. Va. Additional information may be obtained from society headquarters, 20 North Wacker Drive, Chicago 6, Ill.

May 27-29—

American Society for Quality Control. Seventh annual convention to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from society headquarters, 70 East 45th St., New York 17, N. Y.

May 27-28—

American Iron & Steel Institute. Annual meeting to be held at the Waldorf-Astoria Hotel, New York, N. Y. Additional information may be obtained from society headquarters, 350 Fifth Ave., New York 1, N. Y.

May 31-June3—

American Gear Manufacturers Association. Annual meeting to be

held at the Homestead, Hot Springs, Va. John C. Sears, Empire Bldg., Pittsburgh 22, Pa., is executive secretary.

June 7-12—

American Society of Automotive Engineers. Annual summer meeting to be held at Hotels Ambassador and Ritz-Carlton, Atlantic City, N. J. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary.

June 8-9—

Malleable Founders Society. Annual spring meeting to be held at the Homestead, Hot Springs, Va. Lowell D. Ryan, 1800 Union Commerce Bldg., Cleveland, O., is secretary.

June 15-17—

American Society of Agricultural Engineers. Annual meeting to be held at Hotel William Penn, Pittsburgh, Pa. Raymond Olney, Box 229, St. Joseph, Mich., is secretary.

June 15-19—

Basic Materials for Industry Exposition. First exposition and conference to be held at Grand Central Palace, New York, N. Y. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N . Y.

June 15-19—

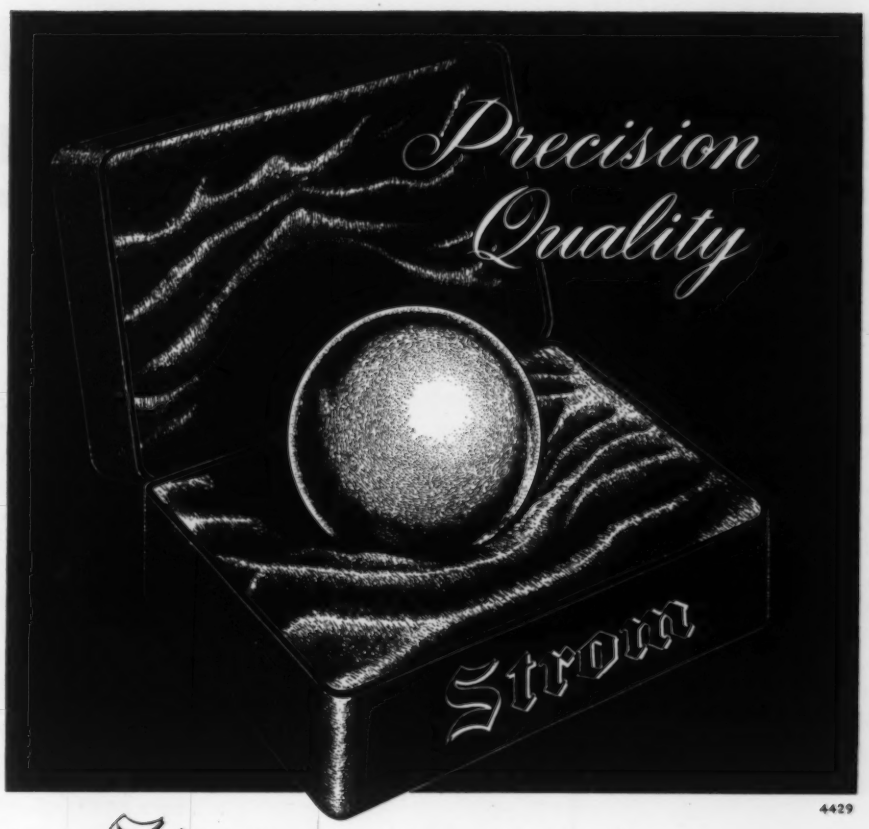
American Institute of Electrical Engineers. Summer general meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

June 16-19—

American Welding Society. National spring technical meeting to be held at the Shamrock Hotel, Houston, Texas. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

June 29-July 3—

American Society for Testing Materials. Annual meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Robert L. Painter, 1916 Race St., Philadelphia, Pa., is secretary.



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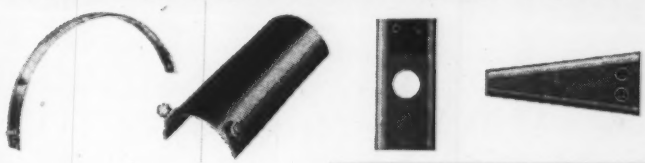

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How many of *your* welding problems are due to a fluctuating voltage? How many? Well, you can eliminate them *all* with LINDE'S electronic voltage control. It holds welding voltage substantially constant at any preset value within the welding range. It responds to increases or decreases in arc voltage by speeding up or slowing down the wire feed motor. This action is practically instantaneous and constant arc voltage results.

The voltage control unit is mounted either locally or remote from the machine. Set up near the welding generator or transformer, it makes the welding head (rod drive and wire reel section) small and compact—easy to handle.

One Knob Control

After making several basic adjustments that set the SWM-3 for a specific job, the machine practically works by itself. Just throw the switch to start welding. It's as easy as that. One simple knob is all you turn.

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3. start feeding down again, maintaining the preset welding arc voltage.

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Because of a high operating voltage built right into the control, the wire feed motor gets ample power for smooth, efficient operation.

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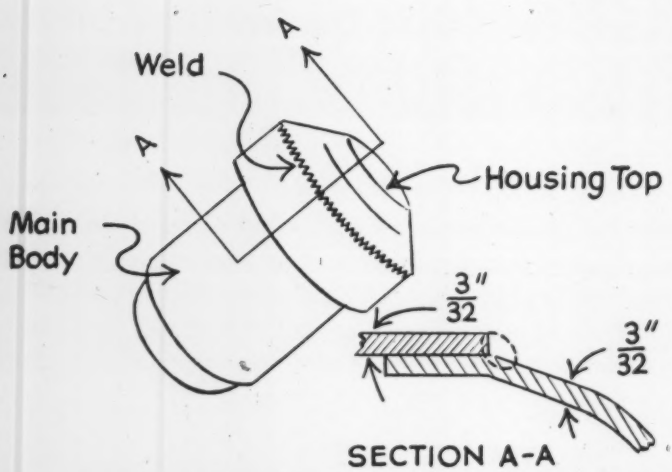

LINDE'S SWM-3 welds most metals fabricated commercially—aluminum alloys, stainless steel, carbon steel, deoxidized copper, Everdur, and aluminum bronze. Butt, lap, fillet, or corner welds are made in these metals from 16 gauge thickness upward.

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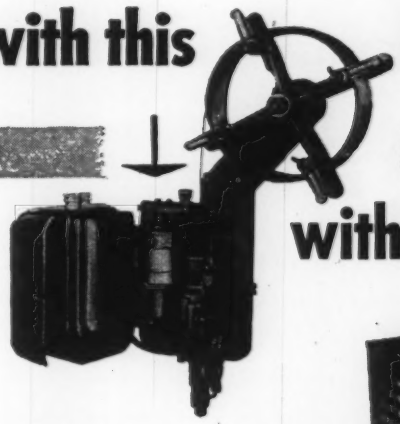

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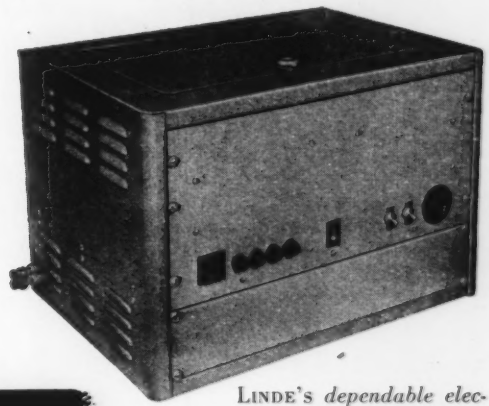

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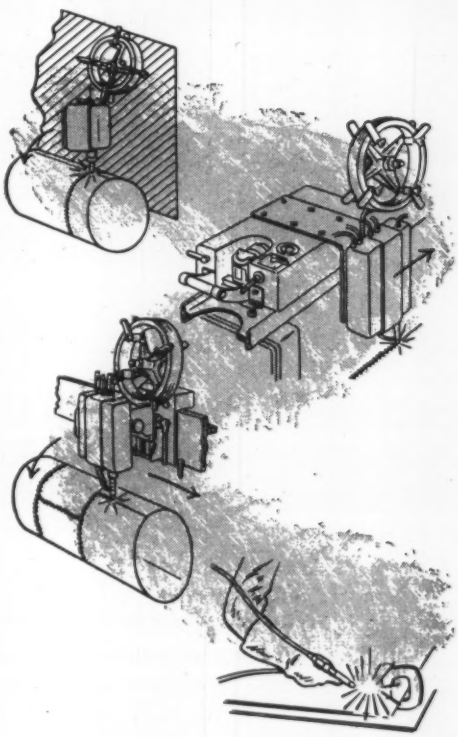

USE IT IN A STATIONARY POSITION

Set up the welding head on a wall, post, or vertical bracket . . . Move the work to be welded beneath it. You can use the SWM-3 for many jobs in this position—it will handle four different sizes of welding wire.

GIVE IT MOTION

Mount the welding head on the OXWELD CM-37 tractor-type machine carriage . . . The SWM-3 will make longitudinal welds in cylinders, or butt, lap, and fillet welds in aluminum and stainless or carbon steels.

COMBINE BOTH SETUPS

It's just as easy to mount the SWM-3 on the OXWELD OM-48 side beam carriage: Use it for making longitudinal welds in any part. Stop the unit, revolve the work, and you can make circumferential welds in the same part—*without changing the setup.*

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By adding an adaptor, you can use the SWM-3 with your sigma hand welding torch. It becomes a flexible drive unit to help you handle all of your other jobs that do not lend themselves to mechanization.

Ask LINDE to tell you more about the SWM-3 . . . There's a good chance that it will help you do one of your present welding jobs better, easier, faster, and cheaper. Telephone or write the nearest LINDE office today.

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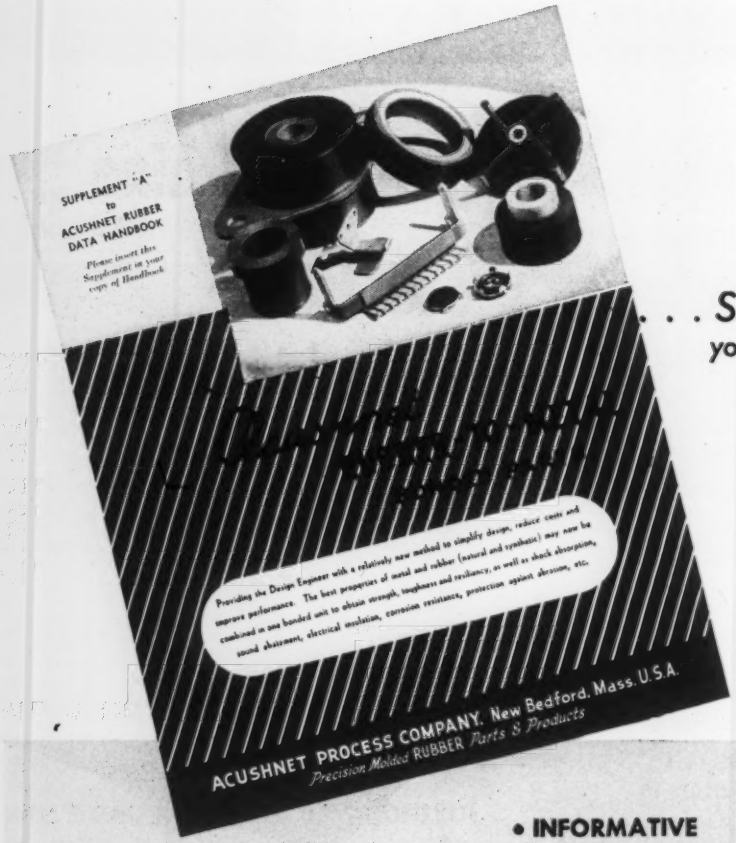

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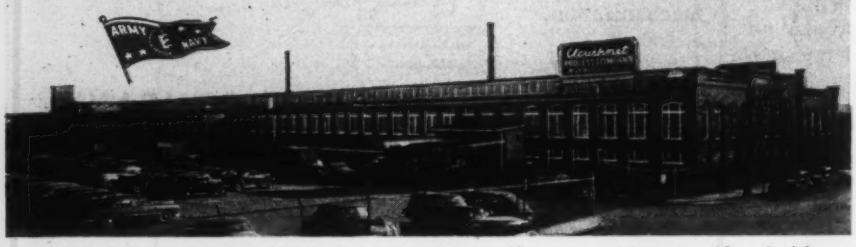
As adhesion can be obtained on most metals, this process provides the design engineer with another method to simplify design, reduce costs and improve performance.



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Design Abstracts

(*Continued from Page* 185)

tube and pipe. The larger presses will permit extending size range.

With the large presses tool costs are high and extreme care must be exercised in their use. Adequate backup tools are required to prevent excessive die breakage. An enormous energy is available for use. Well designed tools can utilize it with efficiency, but poor tools spell catastrophe.

Extrusion Practice: A few of the small extrusion presses in this country are operated by the indirect method, but the direct method is the most common and is used for all large presses except in rare cases where a combination of the two methods may be employed. With direct extrusion maximum pressure is required to start the extrusion, decreasing progressively as the operation proceeds.

Direct extrusion has found widespread use principally because tooling is simpler, extrusions of greater width can be produced, surface quality is better, and it is more easily adapted to the use of multiple-hole dies. The large presses are directly tied to several of these factors. Disadvantages of the direct method are: greater pressure requirements, less uniformity of working of the extrusion, and the formation of defects in the last metal to be extruded if proper practices are not employed.

The alloy to be extruded, pressure available, extrusion ratio, temperature of ingot and cylinder, and permissible extrusion speed are all inter-related variables which govern the extrusion process.

Structural Properties: Numerous studies have been made to determine the character of metal flow during extrusion. The results of such studies reach far beyond academic interest as the size of extrusions becomes larger. Practical application of the knowledge gained from metal flow investigations has determined the cause of structural variations and formation of certain defects peculiar to the extrusion process.

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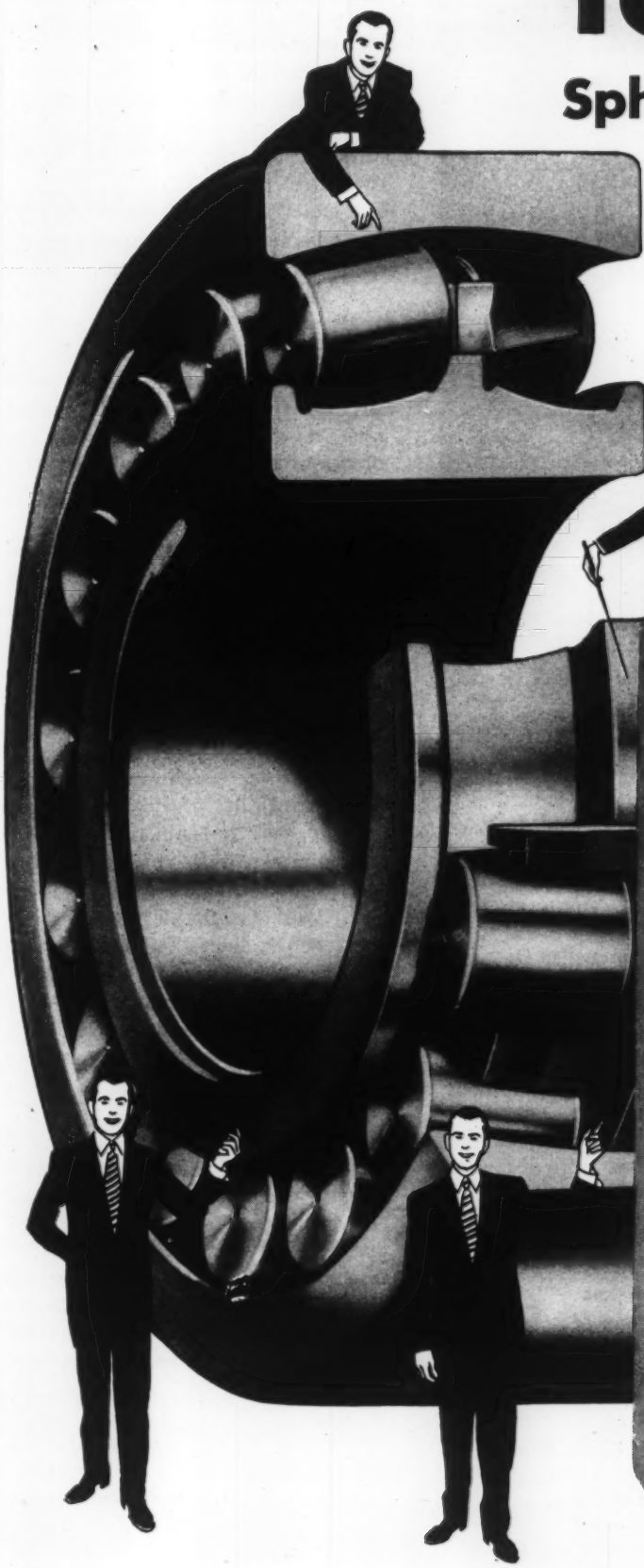

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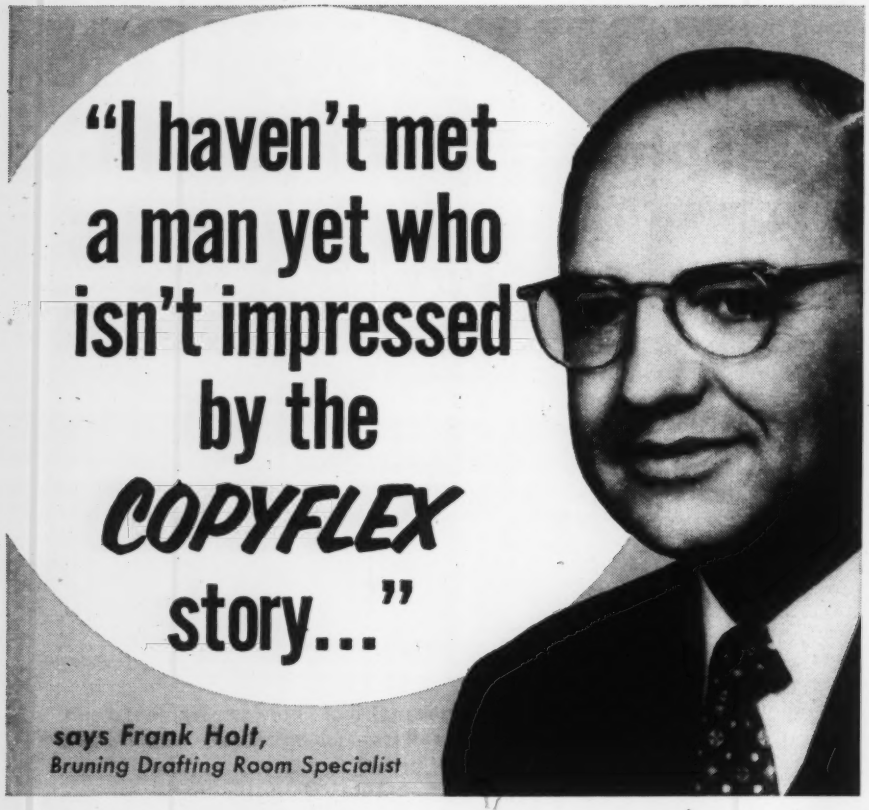

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extrusion receives little equivalent cold work, the amount progressively increasing as extrusion proceeds. Under certain conditions this results in a variation of the metal structure throughout the length. The exact nature of this structure depends upon the extrusion conditions such as temperature, extrusion ratio, size and alloy. For small sections and the softer alloys such structural variations are relatively unimportant, but with large extrusions of the alloy types used for aircraft constructions the effects of each structural variation must be carefully evaluated with respect to mechanical properties. For instance, the extreme front end of a large strong-alloy extrusion will contain remnants of the ingot cast structure and must be removed.

Oriented Grain Structure

The strong aluminum alloys do not recrystallize readily during extrusion or subsequent thermal treatments. With large sections any recrystallization that does occur will be found in an outer band which increases in thickness toward the rear of the extrusion, and the recrystallized band may show relatively coarse grains. The center portion of the shape, and for large 75S shapes the entire cross section, will have an unrecrystallized but highly worked structure which has a high degree of preferred orientation in the longitudinal direction. It is this high degree of preferred orientation that imparts to aluminum alloy extruded shapes high longitudinal tensile and yield strengths above those considered normal for shapes produced by other methods. Extensive use is made of this fact in the design of aircraft structures, particularly wing spars.

Relatively thin sections receive more equivalent cold work during the extrusion operation and are thus more completely recrystallized. Aircraft specifications covering the mechanical properties of strong aluminum alloys recognize this fact and require higher tensile and yield strengths for the larger sections. However, with further in-

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crease in size of extrusion other factors such as decreased extrusion ratio and slower quench rate from solution heat treatment exert their influence, and mechanical properties show a tendency to lower values. This effect is illustrated in *Fig.* 3. Larger extrusion presses will represent a partial solution to this problem.

Information on the longitudinal tensile properties of large extrusions are available from a number of sources. As section size has increased, properties in other directions, particularly transverse properties, have become of greater importance and designers are insisting upon the establishment of minimum specification values for such properties. In developing the reason for lower properties in the transverse and related directions, a similar extrusion was cold worked a slight amount by stretching prior to heat treatment with the result that recrystallization removed the highly preferred orientation effect.

Low Junction Strength

With stepped extrusions, at the point of junction between two section sizes the alignment of the structure will be at an angle to the direction of extrusion. This has a corresponding effect upon the longitudinal mechanical properties, and values somewhat lower than values at points distant from the step may be obtained. However, the direction of metal flow corresponds closely to the direction of applied major stresses when the extrusion is used as an aircraft wing spar. Thus, no impairment to permissible design values is indicated.

At the rear of an extrusion produced by the direct method there may be found two abnormal conditions if the extrusion process is carried beyond what is considered good practice. One of these conditions, often termed "the extrusion defect", is a conical shaped cavity increasing in diameter toward the rear. The other abnormality which has been called "the ring condition" may occur earlier in the extrusion and its control is more difficult. Its source lies in

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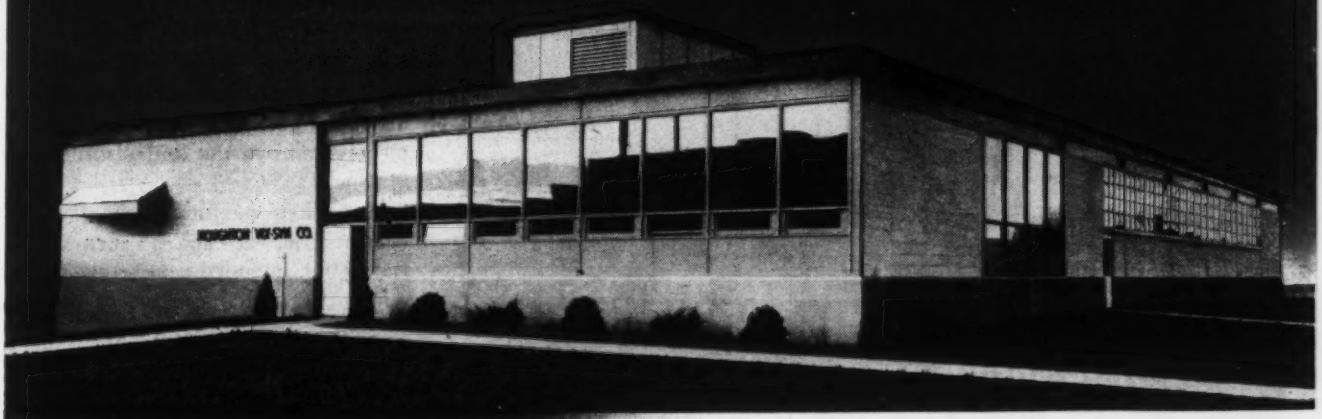

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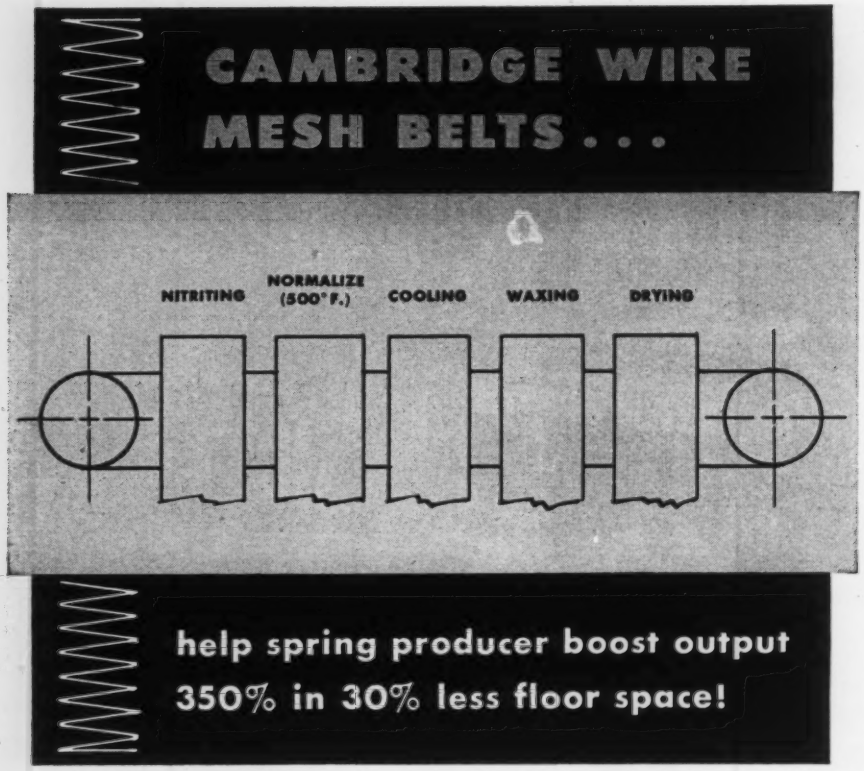

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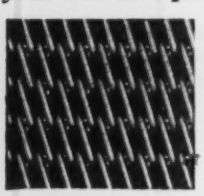

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Design Abstracts

the surface of the ingot and in the flow pattern developed by extrusion. If the ingot surface contains oxide inclusions or other defects to a considerable depth, the ring condition may be found before half of the metal is extruded, but normally it is confined to the extreme rear. As ingots and sections become larger, more rear end discard on a percentage basis of the ingot length is required to completely remove the undesirable conditions.

A broken surface normally will occur first at sharp corners or radii, but in more severe cases can cover the entire surface of the extrusion. The breaks result from excessive extrusion speed for the alloy under the temperature conditions existing.

Die lines and pick-up are two other typical surface defects associated with the extrusion process. The die lines are caused by adherence of metal to the die or, in the more usual case, scratches in the die bearing resulting from hard particles being extruded through the opening. They are not particularly troublesome with large aircraft sections. The oxide formed may agglomerate into fair sized particles as it collects and finally adheres to the surface of the extrusion. This type of defect is particularly troublesome with the stronger alloys when it is necessary to use relatively high extrusion temperatures. Thorough cleaning of the die bearing and water cooling of the extrusion tools minimize the occurrence of pick-up.

Of primary importance for the production of high quality large extrusions is the type of ingot stock available. Good ingots must be sound and have uniform fine grained structure free of porosity, segregation, and surface defects. Fortunately, ingot casting has kept in step with the procurement of larger extrusion presses and will not represent any deterrent to their use.

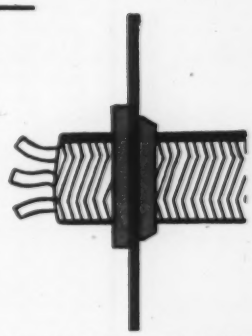
Special Products: In addition to the normal types of extrusions, certain specialties present problems of fabrication far beyond their proportionate share. The advent of

C-D-F *know how*

Designed and Fabricated this DILECTO GROMMET

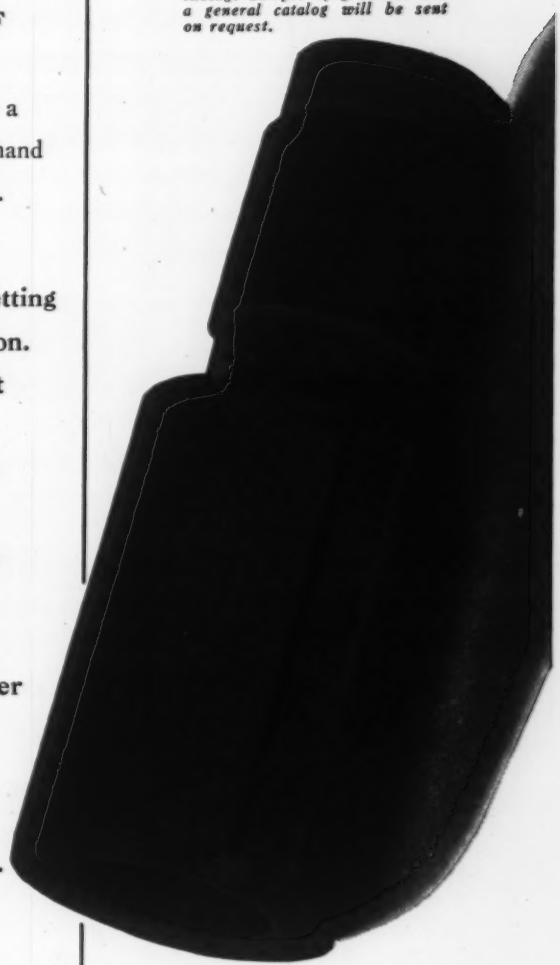
It springs out and holds tight!

Here's an idea and an example of C-D-F engineering skill teamed up with versatile Dilecto — laminated rolled plastic tubing — that can help you. Thousands of Dilecto grommets are being used in the aircraft industry for wire and cables that pass through bulkheads. Made from fine weave canvas, the C-D-F Dilecto grommet is cut into rings. The rings are grooved and beveled, then slit diagonally. The Dilecto grommet has a built-in tension that permits it to be easily compressed by hand and inserted in the bulkhead. Tension holds it tightly in place. It cushions. It insulates. It reduces assembly time.



Here's a side-view of a Dilecto grommet, machined to close tolerances from laminated rolled tubing. Sample of grommet and a general catalog will be sent on request.

DILECTO is a C-D-F top quality laminated thermosetting plastic whose uses are limited only by the imagination. Supplied in sheets, rods, tubes, Dilecto answers most electrical and radio needs for a material that is mechanically and dielectrically strong . . . resistant to high heat, hot oil, excessive humidity. It can be punched, stamped, formed and machined to close tolerances. Investigate its possibilities. Available in many grades to meet a variety of requirements. A qualified plastics specialist, your C-D-F sales engineer (offices in principal cities) will help you engineer a better product. Why not call him today!



Another example of a part machined from Dilecto rolled tubing. Notice variety of machining steps and the possible versatility of this mechanically strong material. Only C-D-F makes Dilecto in sheet, tube and rod forms.

THE NAME TO REMEMBER CDF DILECTO LAMINATED PLASTIC

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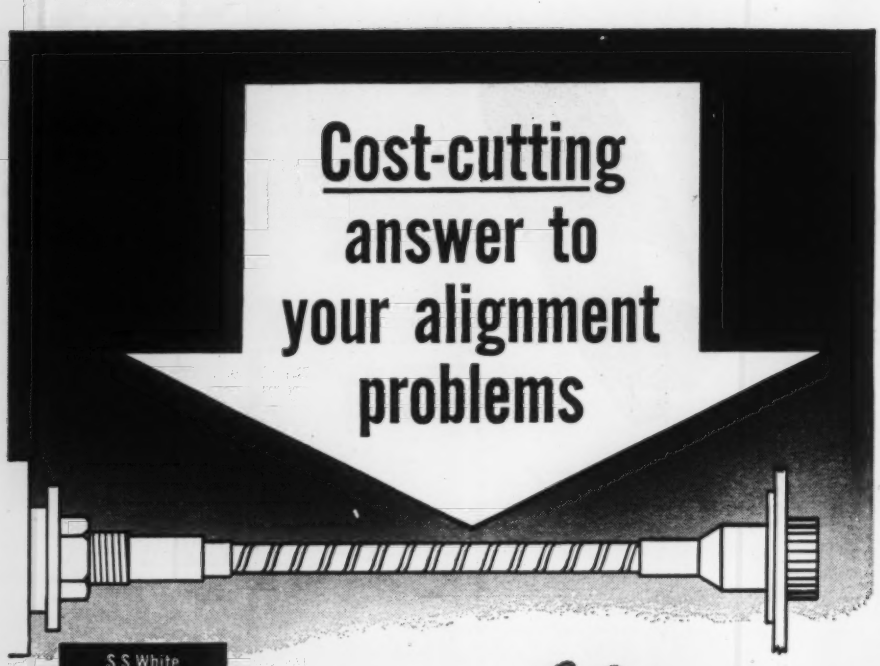
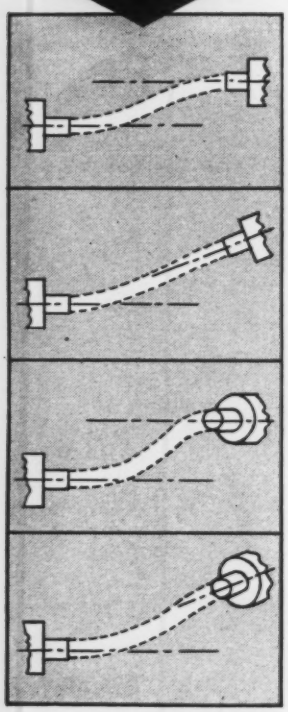
Cost-cutting answer to your alignment problems



S.S.White Flexible Shafts are "naturals" for jobs like these



FLEXIBLE S.S.White SHAFTS

Alignment is never a factor when you use an S.S.White flexible shaft to transmit power or control between two points. The non-rigid construction of the shaft automatically compensates for any misalignment that may exist — and thereby eliminates the costly machining and assembly and many of the operational difficulties often experienced with rigid couplings.

S.S.White engineers will be glad to make recommendations regarding the most suitable shaft for your specific problem. Call them in today. There is no cost or obligation.

WRITE FOR THE FLEXIBLE SHAFT HANDBOOK

256 pages of facts and data on how to select and apply flexible shafts. Copy sent free if you write for it on your business letterhead. No sales follow-up will be made unless requested.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. 4, 10 East 40th St.
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

larger extrusion presses will create the possibility for producing many more of such commodities and present the opportunity to exercise the utmost ingenuity in creating useful products.

Stepped extrusions represent a typical large press product. A common type may be seen in *Fig.* 2.

Integrally rib stiffened aircraft wing panels have been the cause of much experimentation with the extrusion process. Several schemes have been tried with good results. The extrusion part of the problem is relatively simple, but the straightening required to obtain the necessary flatness presents more difficulty. With present presses the limit for such extrusions is about 27 inches wide, but with the installation of the new 13,200 ton extrusion press it is conservatively estimated that this can be increased to 34 inches. Some of these sections are shown in *Fig.* 4.

The extrusion process, when conducted with proper controls, produces a product of high quality and good mechanical properties. Sections may be simple or complicated, balanced or unbalanced, symmetrical or nonsymmetrical, solid or hollow and the process comes very close to satisfying all the whims and fancies of the design engineer.

From a paper entitled "Large Extrusion Press Operation and Production Problems" presented at the ASME Annual Meeting in New York, N. Y., December 1952.

The Practical Side of Space Flight

By Milton W. Rosen

Director
Viking Rocket Project
Naval Research Laboratory
Washington, D. C.

THERE is a saying among the rocket technicians who meet and discuss their work at White Sands—a phrase which goes like this, "You have either just had trouble, or you are now having trouble, or you are about to have trouble." A few successful flights have received wide publicity; the

(*Continued on Page* 289)

(*Continued from Page* 284)

public seldom learns about the many rockets which do not fulfill predictions. Nor is it explained that great odds were overcome to produce a record flight—a flight that would have been nullified by the failure of one component in several thousand. In a rocket—everything must work.

Limitations: Why is it so difficult to go much higher than we have been? It is because the engineers have caught up with the scientists. It is because they have almost exhausted our store of basic knowledge. The time lag between the discovery of a new material, technique or principle and its utilization has become increasingly short.

The public has now come to expect a constant flow of products each more wonderful than its predecessor. But the engineer who has drawn the ingredients from the cupboard of basic research now finds that the cupboard is bare. He must wait for new ingredients.

This is why plans for space travel and designs for space ships are based on a meager store of scientific knowledge and a large amount of speculation. Now there is a place for speculation—if it is clearly labelled as speculation, and if its purpose is to stimulate interest in the subject. But I can hardly conceive of anything that would do more harm to this country's defense effort, and to the cause of space flight itself, than for the United States to undertake any one of the fantastic projects for a space ship that have been proposed in the last few years.

Fundamental Considerations: Altitude is the primary factor in any consideration of the feasibility of a manned, earth-returnable rocket. Two altitudes, 15 miles and 50 miles are significant because they define the boundaries of three regions that can be considered separately. These are the regions between the ground and 15 miles where feasibility has been demonstrated, the region between 15 and 50 miles wherein feasibility can be shown, and the region above 50 miles where a decision on feasibil-

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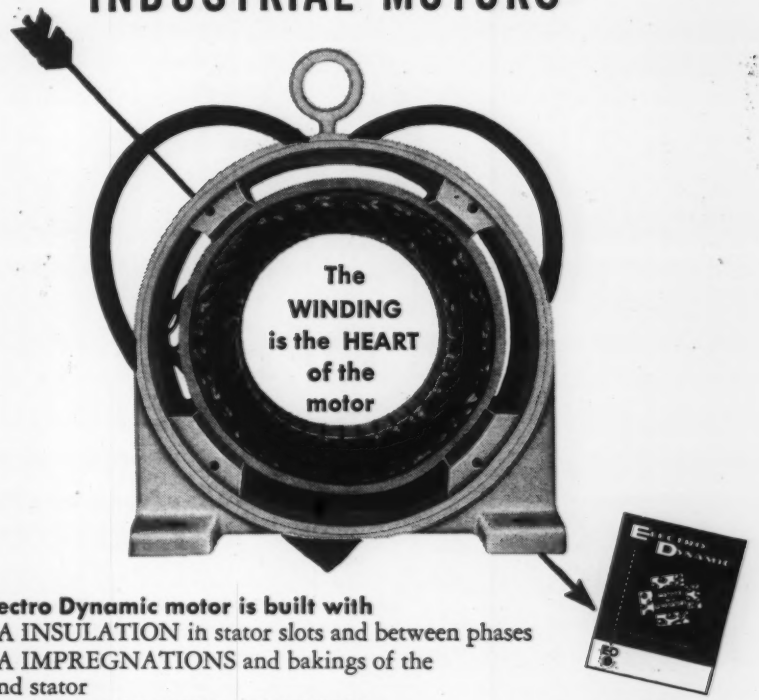
INDUSTRIAL MOTORS



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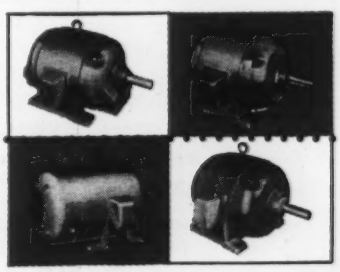
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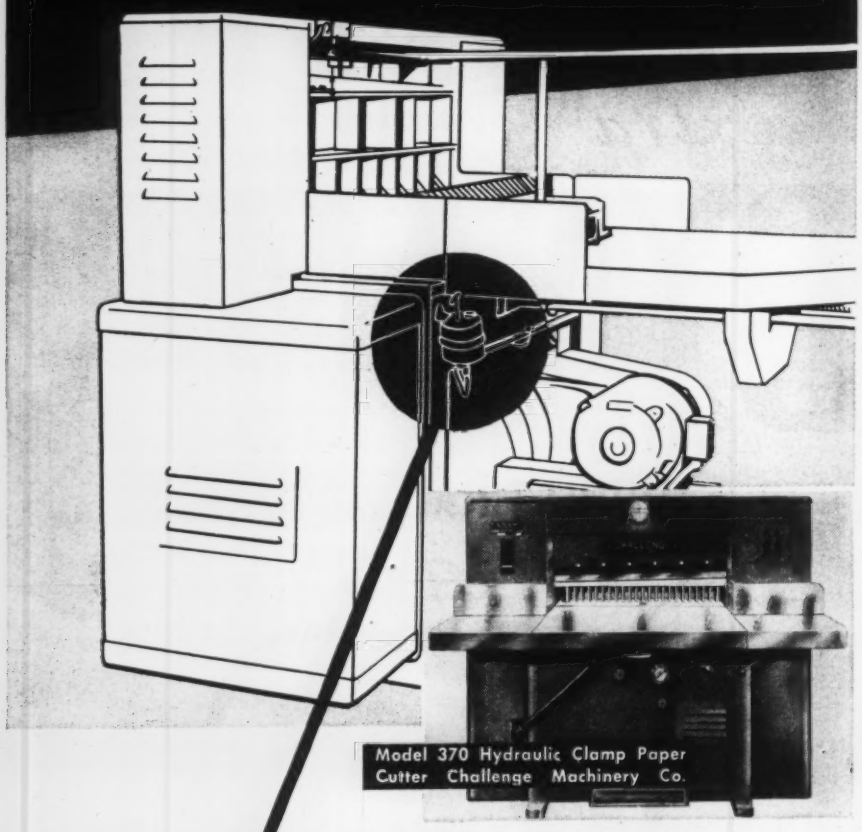

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Pioneers in Automatic Lubrication 238

Design Abstracts

ity is not possible today.

According to recent unofficial, but reliable reports, a Douglas Skyrocket has reached an altitude of 15 miles and its pilot has returned safely to the earth's surface. For an altitude of 15 miles, then, feasibility has been demonstrated. No more needs to be said.

Space Flight to 50 Miles

Feasibility can be shown for a manned earth-returnable rocket that reaches an altitude of between 15 and 50 miles, even though no human has ever reached these heights. Rockets have been built which can ascend 50 miles and which can carry the necessary payload involved in transporting a human being. The significance of the 50-mile height is that parachute recovery has been successful below this altitude. Entire Wac Corporal rockets and instrument sections from Aerobees have been recovered by parachute from altitudes up to 50 miles. The accelerations encountered on the powered ascent are within the tolerance limit of human beings. The maximum velocity is sufficiently low that, for a vertical ascent, the vehicle skin temperature will not tax the capacity of known materials and techniques of construction.

The most important feature of a flight to less than 50 miles is that the duration of flight will be brief—a matter of several minutes. For this reason, many of the difficult problems that would be involved in flights to higher altitudes will be ignored when the altitude limit is only 50 miles. These problems include the effects on the vehicle and its passenger of cosmic and solar radiation, meteor collisions and free fall in a vacuum. Because the flight time is so short, it will not be necessary to make elaborate provision for the necessities of life: food, oxygen, elimination of wastes and maintenance of ambient temperature. The most important problem in this region is one of reliability.

In considering the feasibility of building a manned, earth-returnable rocket for altitudes between 15 and 50 miles the important

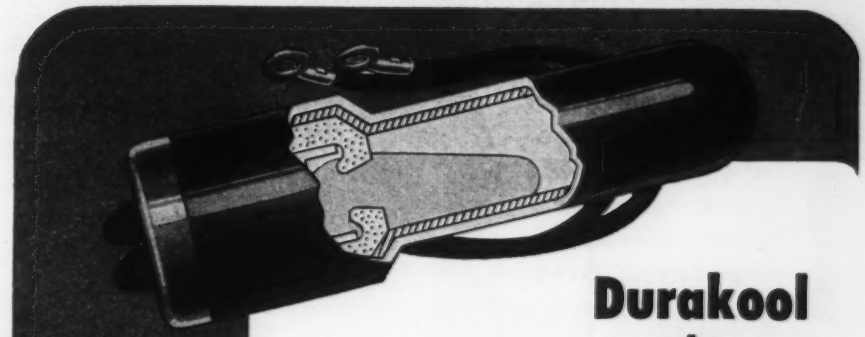
words are *man* and *return*. The reliability of the vehicle must be weighed against the man's chance for survival. This concept of reliability must enter into the design of every component, subassembly and operating system of the vehicle. The factors of safety here are entirely different from those presently used in the design of sounding rockets. The probability of returning a man safely 99 times out of 100 is a very much smaller number than the probability of a safe return 1 time in 100. For the region between 15 and 50 miles, then, the important question to be answered is not whether a manned rocket can reach the required altitude, but whether the same man can make two flights.

Beyond Return: Above 50 miles the situation is entirely different. Attempts at parachute recovery of instruments have not been successful. Depending upon the altitude to be reached, the accelerations could be beyond human tolerance limits and vehicle skin temperatures above the melting points of available materials. The Viking rocket, which reached an altitude of 136 miles, could have carried a man, but no one could have ensured his safe return—no one could have calculated the probability of his survival.

If the duration of flight is sufficiently long, the effects of cosmic and solar radiation must be considered. The nature and quantity of these radiations in outer space have not been fully determined, and we are only beginning to study their effects on living cells. The probability of meteor collisions has been estimated and various schemes for eliminating this hazard have been proposed, but never tested.

It is not possible to predict the physiological and psychological effects of a prolonged weightless state on a human being. If the flight time is long, as it will be when we speak of very high-altitude rockets, satellites, and space ships, elaborate equipment will be required to provide the human being with the necessities of life. A continuous power source will be

(*Continued on Page* 296)



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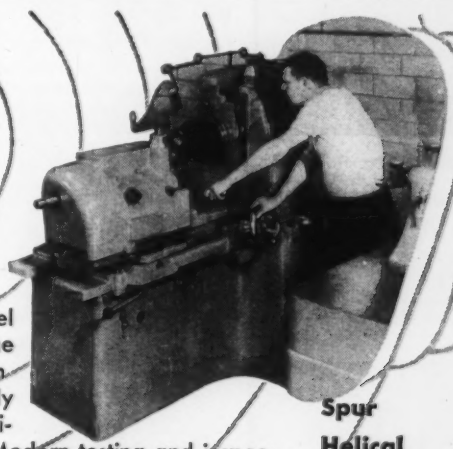

Because minimum noise level is so important in some applications, we will—whenever required—individually *sound check* gears for maximum silence in operation. Modern testing and inspection equipment—such as that illustrated—is available to electronically check gears for exacting noise limits, under a specified load and RPM. Through such thorough inspection quiet operation is *assured*.

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THEY SAY THAT SOME SHEAVES CAN EASILY BE MOUNTED IN ONE PIECE AND GIVE THE SAME SHAFT GRIP AS THE TWO-PIECE DESIGN
NO, CHARLIE... LISTEN- THE SHEAVE THAT GRIPS THE SHAFT TIGHTEST IS THE ONE THAT'S DESIGNED TO BE MOUNTED IN TWO PIECES!

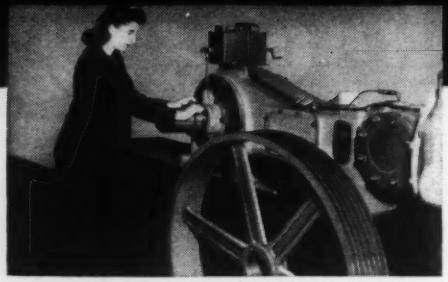

FIGURE 1—TO MOUNT THE QD IN TWO PIECES you (1) slide the split hub on the shaft, (2) position it with the locking clamp-screw in the flange, (3) draw down on the set-screw over the key (QD exclusive) to prevent it from drifting, (4) slide the QD rim with its large taper bore opening up on the taper of the hub, (5) draw up on three heavy hex-head pull-up bolts for a tighter grip than you get with any other sheave.

FIGURE 2—TO MOUNT THE QD AS A UNIT where a Woodruff key is used in a shouldered shaft, you (1) locate the loosely assembled hub and rim of the QD sheave against the shaft shoulder and (2) draw up on the three heavy hex-head pull-up bolts. That's all there is to it. And you haven't sacrificed any grip on the shaft. For removal, you simply use pull-up bolts as jack bolts in specially tapped holes.

Let's settle this one RIGHT NOW!

You can't have your cake and eat it too.

A one-piece sheave assembly may grip the shaft sufficiently tight for average use, but it *won't keep the shaft key from drifting*. Your answer to this problem lies in an *exclusive* key set-screw in the hub of the *two*-piece Worthington QD* Sheave. The set-screw is tightened with the hub on the shaft before the rim is slipped on (figure 1).

Of course, if you use a Woodruff key in a shaft with a shoulder, drifting of the key is no problem and you then can mount the Worthington QD assembled in *one* piece *without any sacrifice of its famous friction-cone grip* (figure 2).

WORTHINGTON'S COMPLETE LINE OF MULTI-V-DRIVES includes QD sheaves in all sizes, QD Juniors and other fractional horsepower V-pulleys, as well as Worthington-Goodyear V-belts. Your distributor has complete stocks backed by the largest factory stocks you'll find anywhere. Write for Bulletin V-1400-B7F to Worthington Corporation, Oil City, Pennsylvania.

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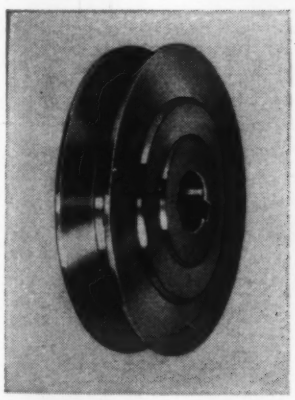
The QD Junior V-Pulley for fractional-hp applications offers all the advantages of its big brother

TRADE MARK

Here's the popular Worthington QD principle applied to a fractional-hp V-pulley! It will grip the shaft tighter than any other V-pulley now available. The cutaway shows how tightening of the large nut causes the taper-bored rim to force the tapered hub *tight* on the shaft. Removal is just as simple.

No matter what your fractional-hp V-pulley needs WORTHINGTON has an answer . . .

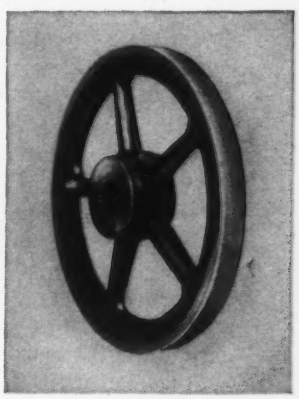


Machined Steel V-Pulleys —3½ in. and under

Precision-bored for proper fit on shaft. Belt seats properly, wears longer in accurately cut groove.

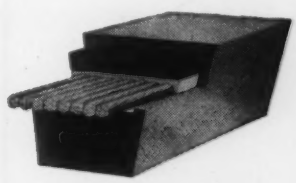
Pressed-Steel V-Pulleys

Heavy gauge, welded steel. Equal weight distribution assures accurate balance and vibrationless operation.



Cast Iron Bored-to-Suit V-Pulleys

Accurately machined for true running and perfect balance. Full range of sizes with one or two grooves.



For smoothest performance from V-belt drives use WORTHINGTON-GOODYEAR EC Cord V-belts

Each cord carries its equal share of the belt load, each belt—its equal share of the drive load. A complete line. Also steel-cable belts for high capacities, HY-T cord belts for shock loads, and FHP belts.

GET MORE OF THE FACTS

For all the facts write today for: Bulletin V-1400-B7F on stock sizes and specifications of Worthington QD sheaves and Worthington-Goodyear V-belts. Bulletin FHP-100 on FHP pulleys and V-belts. Worthington Corporation, Oil City, Pa.

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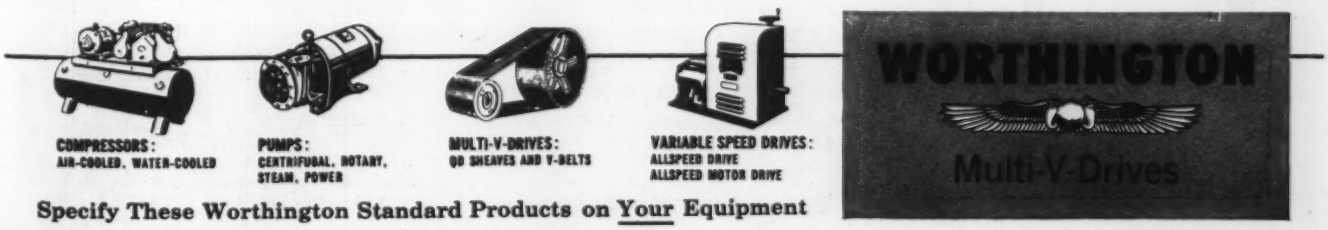
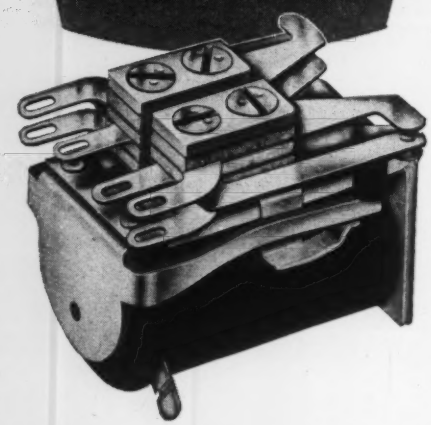


Specify These Worthington Standard Products on Your Equipment

115 million cycles without a breakdown!



Torture Test Proves COMAR RELAYS are Tough

Illustration shows a typical Comar Telephone Type "TM" Relay recently subjected to exhaustive tests by a Comar user. Results: 115 million cycles without a breakdown!

Comar relays stand up under severest operating conditions. They are engineered to far exceed normal performance and circuit requirements. Precision workmanship and top quality is your assurance of dependable operation. Comar specializes in relays custom-engineered to fit your needs. Send specifications for our recommendations, no obligation.

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Design Abstracts

(*Continued from Page* 293)

needed for the operation of such equipment. Since the flight may impose terrific physical and psychological strains on the passenger, it is expected that all equipment necessary to power and guide the vehicle, to provide the necessities of life, and to ensure the passenger's safe return—will have to be automatic in operation.

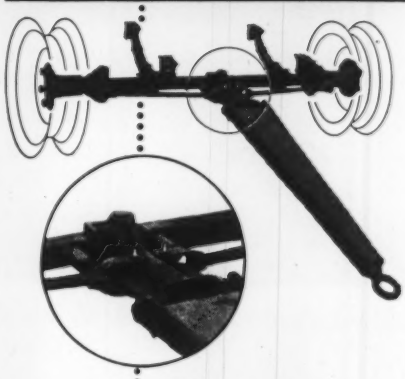
Feasibility will have to be shown for every one of these machines—machines which will have to perform a diversity of functions with great precision. A tremendous amount of investigation, measurement and test will have to be conducted before one can assess the magnitude or importance of most of the problems involved. The discussion for altitudes above 50 miles leads to the inevitable conclusion that, at the present time, we cannot even estimate the feasibility of building a successful manned rocket, because of the insufficient data available.

Future Outlook: If we cannot build a space ship today, what can be done to advance the cause of space travel? We can do much. We can discover the ingredients for future engineering. We can replenish the cupboard of basic research. Before we can attempt to transport human beings in a ship that orbits around the earth, we must produce a practical, reliable, unmanned satellite. To do this, better, more efficient rocket power plants are needed, and our progress in recent years has been slow.

Anyone who can operate a few machine tools can build a rocket motor and make it work. It is one of the simplest engines for converting chemical energy into mechanical energy. But no one fully understands the theory of combustion in a rocket motor. This is one reason why every rocket manufacturer in the country is having difficulty in improving his product. We need more research on fuels, on high-temperature metals and ceramics, on novel methods for cooling the inner walls of rocket motors and the outer skins of high-speed airframes.

Atomic energy has been envi-

UNITED CARAVAN AXLES



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Stability for the heaviest loads is provided by massive center steering arm, extra-heavy center arm stop blocks and heavy duty steering knuckle. Wide inside wheel turning angle assures maximum maneuverability and eliminates jack-knifing.

CARAVAN units are available in a variety of types and sizes in both 2 and 4-wheel assemblies for portable equipment weighing from 500 to 14,000 lbs. They are recommended for use with military and industrial as well as field service and construction equipment. 1123-UM

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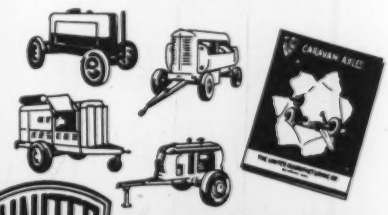

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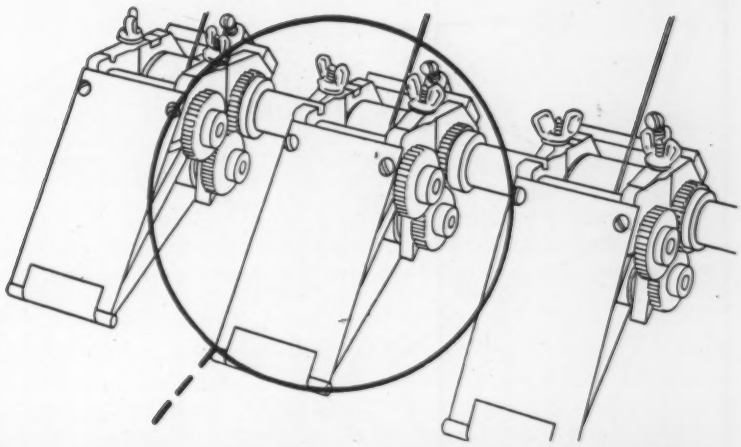
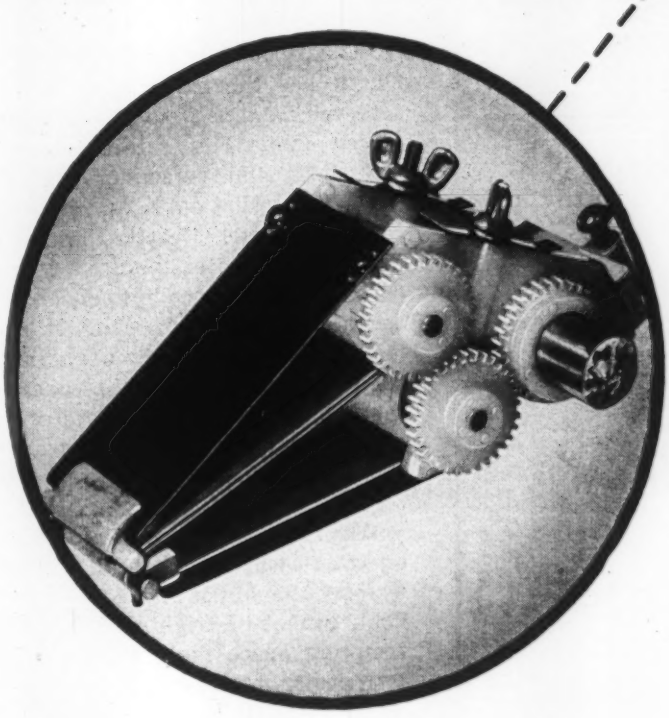


Parts of Du Pont nylon stop yarn contamination



Parts molded for
Macdonald and Sons, Inc.,
by Plastic Mold and Engineering Co.,
both of Providence, R. I.

in textile spinning process, need no lubrication, last longer, improve yarn quality

In the textile industry, long draft units—200 to 400 per machine—are used to finish rough yarn during the spinning process—give it strength and uniformity. The moving parts of these units have always proved troublesome. They wore and abraded . . . required oiling. Resultant yarn contamination was a constant problem. Maintenance required complete machine stoppages to remove and replace one unit. Production suffered . . . costs increased.

In designing an improved unit, as illustrated, Macdonald and Sons, Inc., overcame these problems and developed at the same time a unit that improves yarn quality. They specified that all moving parts and bearing surfaces be molded of Du Pont nylon. The nylon parts need no lubrication, yet they resist abrasion and actually outwear their counterparts by several times. Du Pont nylon is tough . . . does not chip or crack . . . can operate continuously to 250°F. It absorbs shock . . . damps noise and vibration. And nylon's strength and resiliency allows the operator to remove and replace units while the machine is operating, without damage.

Du Pont nylon helps produce a better yarn, free of contamination. Costs are lowered . . . production is increased.

Perhaps Du Pont nylon's unique combination of properties can help you improve a product or a process. For full information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 125, Du Pont Bldg., Wilmington 98, Delaware.

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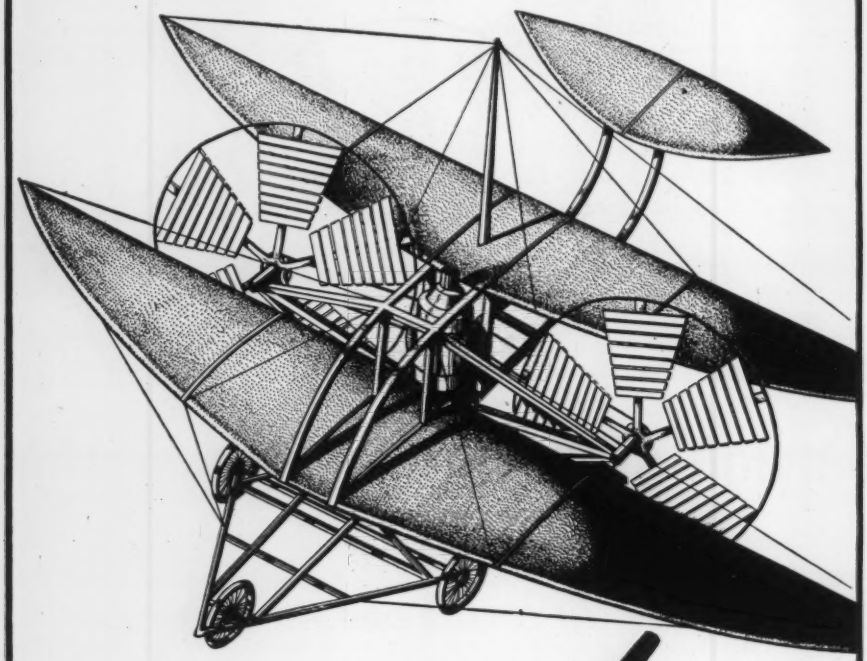

...out of this came Aviation

...a precision industry

To serve this great industry a manufacturer must maintain the best and most modern equipment available, operate it with skilled craftsmen, and use every existing method of tightening specifications and cutting production costs. Indiana Gear is such a manufacturer—a company of craftsmen producing fine quality transmissions and actuators for industry.

This is the control panel room in I. G. W.'s ultra modern heat-treating department—one of the contributing factors to Indiana Gear's unique ability to create hard-to-make parts to exacting specifications.

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sioned as an almost limitless power source for the propulsion of a rocket. The application is important, but its value has been greatly overestimated.

Some restrictions for present-day rockets still apply. There is a practical limit on the temperature at which a rocket motor can operate and it matters little whether the heat has been generated by nuclear or molecular reactions. All rockets are propelled by the ejection of matter and our atomic rocket will have to carry a working fluid. This fluid can have lower molecular weight than the exhaust gases of a chemical combustion and herein lies the major gain to be achieved from the use of a nuclear power plant. The protection of instruments and personnel against damaging radiation is an obstacle to be overcome. Despite these difficulties, the potential use of nuclear power for the propulsion of rockets cannot be ignored. It remains to investigate the use of nuclear rocket power in the laboratory and in the test pit, before we construct the first atomic-powered rocket vehicle.

Why?: Now comes the important question—why do it at all? This country should not and, I feel confident, cannot be frightened into attempting space flight before it is technically feasible. The alleged military value of a space ship is as speculative as today's space-ship designs. Also we can only speculate about the material benefits that might be derived from the exploration of the unknown regions of outer space.

I am reminded of Aesop's Fable about the farmer and his sons. A farmer, being on the point of death and wishing to show his sons a way to success, called them to him and said, "My children, I am now departing from this life; but all I have to leave you, you will find in the vineyard."

The sons, supposing that he referred to some hidden treasure, as soon as the old man died, went to work with their spades and plows and turned up the soil over and over again. They found, indeed, no treasure; but this thorough till-

Cutaway view of an Ortman Miller Machine Co. Standard Hydraulic Cylinder showing PARKER O-rings.

Specify PARKER O-rings for economical, leakproof seals

THIS IS IT

Cross section drawing of O-ring in groove, sealing under pressure.

For sealing in a hydraulic cylinder . . . or for whatever service you need them, you can get PARKER O-rings, molded of expertly formulated synthetic rubber compounds, that will provide long, trouble-free sealing life. That means they are economical to use. They're economical, too, because they require no complicated design . . . just a simple groove, usually saving space and weight.

PARKER makes *all* standard O-rings for fuel, hydraulic and engine oil services as well as special-service O-rings. Ask your PARKER O-ring Distributor for Catalog 5100, or write The PARKER Appliance Co., 17325 Euclid Ave., Cleveland 12, O.

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Small Motor Brush Clinic

...for longer life, greater efficiency

No doubt, you're getting pretty good brush life and performance on small motor applications these days. *But, chances are still mighty good that they can be materially improved—at no premium cost.*

Recently, for instance, Stackpole brush developments brought about worthwhile improvement on such widely diverse equipment as toy trains, a coal drill, a d-c gas pump motor and an ac-dc inverter.

These jobs were handled the way Stackpole likes to handle them: *by getting the actual motorized equipment into our laboratories for "clinical" test.* Here, Stackpole engineers combine the greatest wealth of small motor brush "know how" in the business with carefully planned experimentation. They recognize that each brush application differs from others in essential respects. These peculiarities are taken into full account in developing grades exactly suited for the equipment in question. And, more often than not, they come up with a brush recommendation that is an improvement over what has been used in the past.

NOTE: Stackpole brushes are sold only to manufacturers of original equipment.

Write on company stationery for the 44-page Stackpole BRUSH USERS' GUIDE.

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

STACKPOLE

age yielded a firmer vintage than they had ever reaped before and more than repaid the young husbandmen for all their trouble.

Similarly with space travel; the knowledge we will have to gain, the techniques we will have to master, the machines we will have to build —will bring more material benefit to the earth's population than any gold or uranium we may find on Mars or Venus. The value of space flight is in the doing of it.

From a paper entitled "A Down-to-Earth View of Space Flight" presented at the Second Symposium on Space Travel at the Hayden Planetarium in the American Museum of Natural History, New York, N. Y., October 1952.

Energy Method of Electrical Analysis

By P. L. Alger and W. R. Oney

Small and Medium Motor Dept.
General Electric Co.
Schenectady, N. Y.

THE polyphase induction motor still presents challenging problems, both practical and theoretical, despite the progress made in the 66 years since Telsa invented it. A present-day 30-hp motor is built in the same overall dimensions as the 20-hp motor of 25 years ago or the 5-hp motor of 50 years ago. It's more reliable, versatile, and better in every respect including looks. Yet, customer demands and economic pressures require that progress continue. To this end better theories, as well as better materials and methods, are certainly primary requisites.

Design Problems: The chief problem in induction-motor design is obtaining high torque all the way from rest to full speed, and along with it also obtaining low starting current, low losses, and quiet operation. A first step in the solution is to employ some form of double-squirrel-cage rotor winding. This consists of two squirrel cages placed one outside the other. The outer winding has a high resistance and low reactance; the inner wind-

ACADIA *Silicone* RUBBER

Acadia Silicone chemists have at last provided a material that stands extreme heat and increased tensile strength for better compression. Other advantages are resistance to fungus, ultra-violet rays, strong acids and oils. Its dielectric properties are excellent. It is odorless and stainless.

Acadia Silicone is now available molded or extruded for such components as gaskets, seals, "O" rings, washers, sheet, tubing, cut-parts, packings to meet extraordinary service.

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5. Large low rate release springs well removed from heat source.
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Twin Disc announces the first of a new series of air-actuated clutches. Available now in two and three plate 24" sizes, the new model clutches possess many outstanding design features for greater performance.

To meet installation limitations, they have been designed for minimum weight, width and inertia mass—yet with even greater torque capacity.

Air-cooled release springs, operating in conjunction with new flat release valves employing a proved diaphragm seal, provide positive, quick-action release. Transmission of clamping force through slotted asbestos plate for adequate insulation, assures long diaphragm life.

Why not specify Twin Disc on your designs requiring air-actuated clutches? Contact your nearest Twin Disc Factory Branch Sales Office or the Factory for engineering recommendation.

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Design Abstracts

ing has a low resistance and high reactance. In this way the rotor current at standstill is made to flow chiefly in the high-resistance outer bars, while at speed the current takes an alternate path through the inner bars of low resistance but high inductance. The effective rotor resistance therefore is high at start and low at speed, giving high starting torque with low I^2R losses in normal operation.

After taking this first step, however, there is still a big way to go before the torque problem can be solved. The stator and rotor windings of an induction motor are located in slots separated by a small air gap. The air-gap magnetic field therefore has a highly ragged wave shape. Besides the fundamental flux rotating at synchronous speed, there are many harmonic fields with large numbers of poles that rotate at low speeds. These produce parasitic torques that somehow must be held within practical limits.

Theoretical Analysis: Usually, motor theory is taught, and design calculations are made, with equations expressing the torque as the product of rotor current by magnetic flux density in the air gap. You can gain a deeper understanding of the performance however by the energy method of analysis. This method traces the flow of electric energy over the incoming power lines, its transformation into magnetic energy in the air-gap space, and its final delivery in mechanical form to the shaft of the driven machine. The procedure is based on the fundamental principle expressed by Kelvin's law:

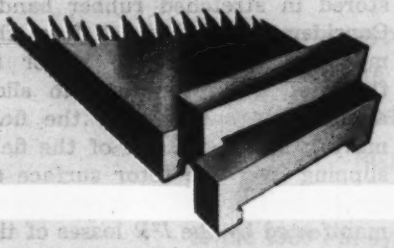
> When in a singly excited magnetic circuit without saturation a deformation takes place at a constant current, the energy supplied from the electric circuit is divided into two equal parts. One half increases the stored energy of the magnetic field; the other half is converted into mechanical work.

In other words, the work done by a magnetic force acting across an air gap is only possible because energy is stored in the magnetic field itself. The magnetic force acting at any point in the air gap

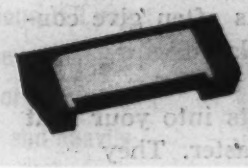
HOW HARD are OK hardened ways?

ONE CUSTOMER SHOWED US BY:

1. Taking a section from an OK bedway



2. Making it into a "tool bit"



3. Then cutting metal with it (1045 cold rolled steel)

The Gisholt Machine Co., Madison, Wisconsin, who use Ohio Knife bedways exclusively on their ram and saddle type Turret Lathes, made the above dramatic test for one of their customers. RESULT—another sale of a famous Gisholt Turret Lathe.

This super uniform hardness on the wear surfaces to a depth of 3/16" (64-66 Rockwell "C") is the reason why more and more OK ways, gibs, races, etc., are being specified on new equipment and used as replacements where former parts have failed. OK ways are practically wear proof assuring constant accuracy throughout the life of your machine. Enjoy with many prominent machine tool builders and users, the long wearing, supreme accuracy, super hardness of OK ways. Many sizes, shapes, etc., available, or made to your specifications.

OK wear strips are now available in welded Ampco bronze.
(Reg. U. S. Pat. Office by Ampco Metal Inc.)

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Write for comprehensive Bulletin to Dept. A

GO WITH OHIO GREEN

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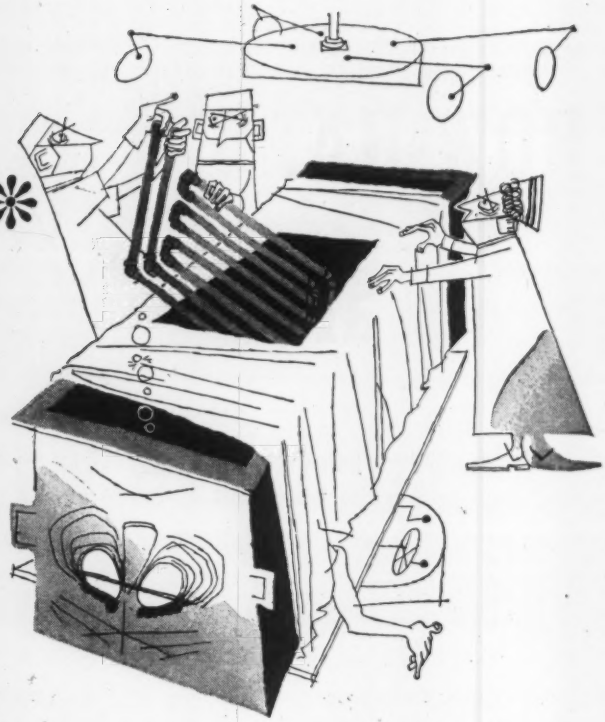
has
coil-itis *
got you
constantly
doctoring
your
tanks?



Like the human appendix, pipe coils often give constant trouble until they are removed and replaced with Platecoils. Immediately, you will notice the difference as Platecoils put new life and profits into your heat transfer processes. They heat or cool 50% faster. They take 50% less space in the tank leaving room for greater payload. Platecoils overcome the limitations and operating difficulties of old fashioned and outmoded pipe coils to save hours of downtime.

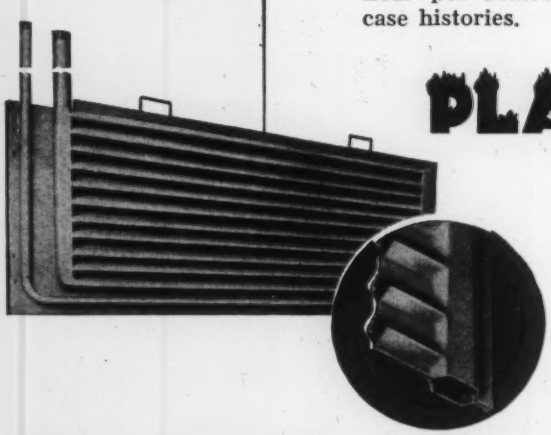
It costs less to cure coil-itis with Platecoils than to suffer its evils.

Write for Bulletin P71 today!

PLATECOILS SAVE 50% IN HEAT TRANSFER COSTS

PLATECOILS REQUIRE 90% LESS CLEANING

At Motor Wheel Corporation cleaning time has been cut from 10 hours per pipe coil every 60 days to only one hour per Platecoil. Ask about other case histories.



PLATECOIL

REPLACES PIPE COILS

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Coil-itis — Diagnosed as tank heating and cooling problems. Platecoils — the prescription for solving pipe coil problems.

PLATECOIL DIVISION, KOLD-HOLD MANUFACTURING CO., LANSING 4, MICHIGAN

Design Abstracts

equals the corresponding space derivative of the stored magnetic energy. By dealing with the total magnetic energy in the air-gap space of a motor, expressions for the forces can be obtained that include all of the harmonic-field effects. The magnetic energy is also a direct measure of the reactance.

Energy Method: It is easy to see how a force pushing down on the piston of an automobile engine turns the crankshaft. It's not easy to see how the air-gap magnetic field of a motor creates a turning effort by taking hold of the rotor currents. Let's therefore replace the intangible magnetic fields by imaginary elastic bands of force. Think of energy being stored in these elastic bands just as it's stored in stretched rubber bands. Consider them to stretch from the magnetic poles of the stator to those of the rotor; and to slide along their surfaces as the field moves. Finally, think of the field slipping over the rotor surface as creating a frictional drag, or torque, manifested by the I^2R losses of the induced rotor currents. The magnetic force is given by the derivative (rate of change) of the stored elastic energy—with respect to the space angle between the field and the rotor current.

The flow of energy across the air gap of a motor is governed by precisely the same laws as the transmission of radio-broadcast waves over thousands of miles of space. In either case the carrier for the useful power flow is the magnetic energy stored in the air spaces (a result of the magnetomotive force impressed by the sending-end currents).

In a turbine the most important thing is the flow of energy-containing gas or fluid through guided paths. Similarly, in an electric machine the important thing is the flow of energy through the magnetized air spaces. A proper model of an induction motor is one formed, therefore, by first immersing the machine in a plastic compound, and then dissolving out all the metal parts with acid—leaving a structure representing only the air and dielectric (insulating) spaces. The

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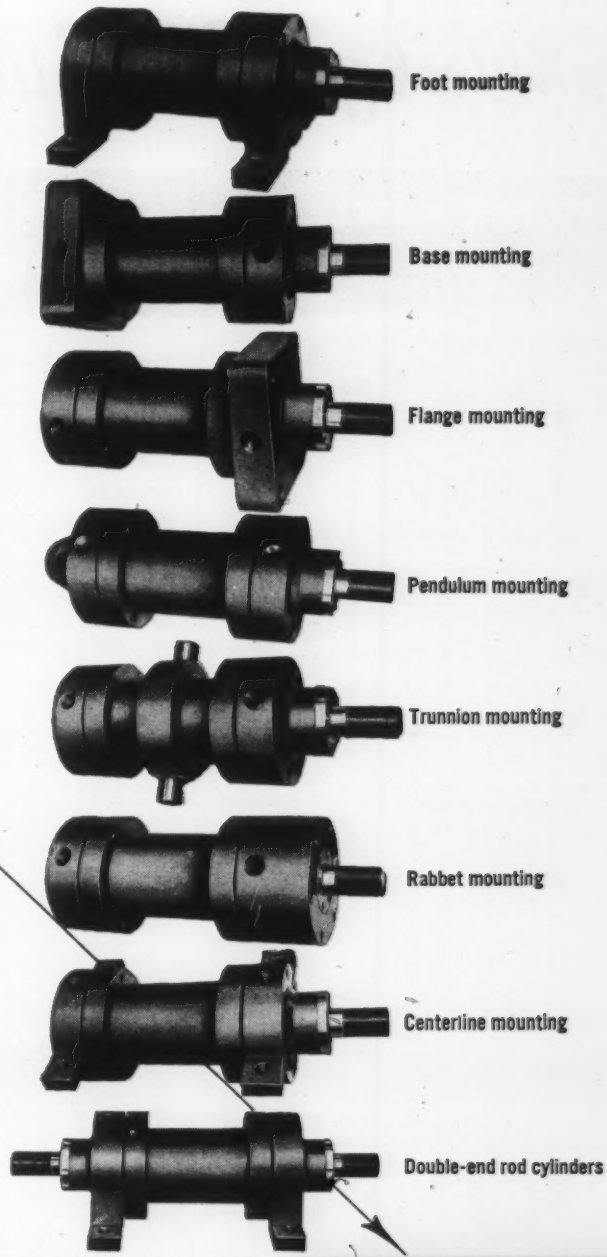
... now available for pressures to 3000 PSI

For extra power applications, it'll pay you to investigate the new Lindberg line of hydraulic cylinders for operation up to 3000 PSI ... ruggedly and heavily designed for extra performance. Added to the 1500 PSI hydraulic cylinders, this line gives you a selection from 0 to 3000 PSI ... and supplements the Lindberg line of air cylinders.



Check these Lindberg features for dependable, low cost power for lifting, forcing, pulling, pressing, pushing and clamping:

ROTATING CAPS ... Caps can be easily rotated in order to position ports for piping. Just remove cap screws, and revolve head cap ... it isn't necessary to disassemble cylinder. This feature permits simplified piping, and frequently eliminates need for T-fittings or elbows.

NO TIE-RODS ... Welded flange construction eliminates need for tie-rods ... insures proper alignment.

PACKING RESISTS OIL AND TEMPERATURE ... Chevron type piston rod packing is made of special asbestos cloth and rubber compound ... resists high temperature ... is not affected by oil.

NEOPRENE O-RINGS ... Conventional gaskets are replaced by Neoprene O-rings. Sealing action is automatic ... the higher the pressure, the tighter the seal.

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Lindberg 3000 PSI Hydraulic Cylinders come in 8 mounting types and 10 bore sizes from 2" to 8".

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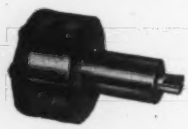
TUTHILL MODEL L Pumps are Built to Meet Specific Needs of Product Designers

MODEL L
For lubricating, hydraulic, transfer, circulating, burning oils service. Built in 5 sizes.

The Tuthill Model L is the pump that introduced the first practical mechanical seal for leak-free performance and low power consumption. This compact, efficient positive displacement internal-gear rotary pump is offered in the following types to fit the pump to the need—in capacities from ⅓ to 6 g.p.m. and pressures to 600 p.s.i.

MODEL LD
For burning oils service. Flanged ports, 3-bolt mounting. Built in 3 sizes. Available also with built-in ball bearings as Model LDK.



MODEL LF
For lubricating service. Flange mounting without shaft seal. Choice of internal or external porting. 3 sizes.

MODEL LH
For hydraulic service. Pressures to 600 p.s.i. 4 sizes.

MODEL LK
For lubricating, hydraulic, transfer and circulating service. Built-in ball bearings. 4 sizes.

MODEL LPV
For lubricating, transfer and circulating service. Built-in adjustable by-pass valve. 3 sizes.

MODEL LSA
Stripped pump for built-in applications in lubricating, hydraulic, transfer and circulating service. Includes Model L cover, idler gear and rotor. 5 sizes.

MODEL RL
Automatic reversing feature permits driving pump in either direction without changing direction of flow or changing port positions. For lubricating and hydraulic service. 3 sizes.

Write for Catalog No. 101 on Model L pumps. Also ask for Tuthill Pump Guide on complete line of Tuthill pumps.

TUTHILL PUMPS FOR THE PURPOSE

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motor designer must shape these air spaces—just as the turbine designer shapes his nozzles and buckets—so that the energy flow will be as frictionless and easy as possible.

To apply these concepts to an induction motor it is logical to consider in sequence: the incoming electric energy from the power system, the magnetic energy stored in the air-gap field, and the mechanical energy transmitted across the air gap.

With the locations and flows of magnetic energy throughout the air spaces in the machine clearly established, it is a relatively simple matter to determine the torques and forces at all points. These are obtained by differentiating the energy stored in each locale with respect to the direction in which the force occurs.

Electric-Hydraulic Analogy

It's convenient for you to think of the flow of electric current in a wire as similar to that of water in a pipe. When the switch is closed (valve opened) at the sending end, voltage (hydrostatic pressure) is applied to the conductor (pipe). Free electrons (water) then rush along the conductor. These electrons build up a pressure of electric potential (bursting pressure) against the insulation (pipe wall) along the way, and create magnetic-field energy in the space around the conductor (kinetic energy of the moving water).

Two conditions arise. If the receiving end is open the electrons meet a potential barrier of air. This barrier throws them back against the oncoming electrons—resulting in a wave of reflected voltage and current that returns to the source. After a series of reflections the system settles down to a steady state with no current flowing. The conductor is now full of electrons pressing against the enclosing wall of insulation.

If the receiving end is closed a similar process of current reflections occurs until equilibrium is reached. With a steady-state current now flowing, some of the voltage pressure is used up along the

SYNTHANE—out of sight, but in the picture

Whenever you turn on television you are using a little-seen, but essential, material called Synthane.

Synthane is a laminated plastic of multiple virtues, which recommend it for many jobs in television.

Synthane is an excellent insulator, laminable with metal, hence, a good base for space-reducing "printed" circuits. Synthane is notable for low power factor, low moisture absorption, and ease of fabrication, three properties desirable for radio and television insulation. Synthane plays a supporting part in many behind-the-screen and behind-the-camera applications.

Synthane is also light in weight, strong, vibration absorbing, chemically resistant, high in dielectric strength, dimensionally stable, heat resistant to about 300°F.

There may be a place for Synthane in your product. To find out more about the possibilities of Synthane for your purpose, write for the complete Synthane Catalog. Synthane Corporation, 7 River Road, Oaks, Pennsylvania.

Synthane laminated plastics are produced under heat and pressure from laminations of resin-impregnated materials such as paper, fabric, glass cloth, asbestos, etc. Synthane plastics are available in sheets, rods, tubes, and fabricated or molded parts. Each of the many Synthane grades has a combination of useful properties.

Synthane in Television . . .

A-Television camera parts
B-Television receiver printed circuits—metal foil on Synthane sheets
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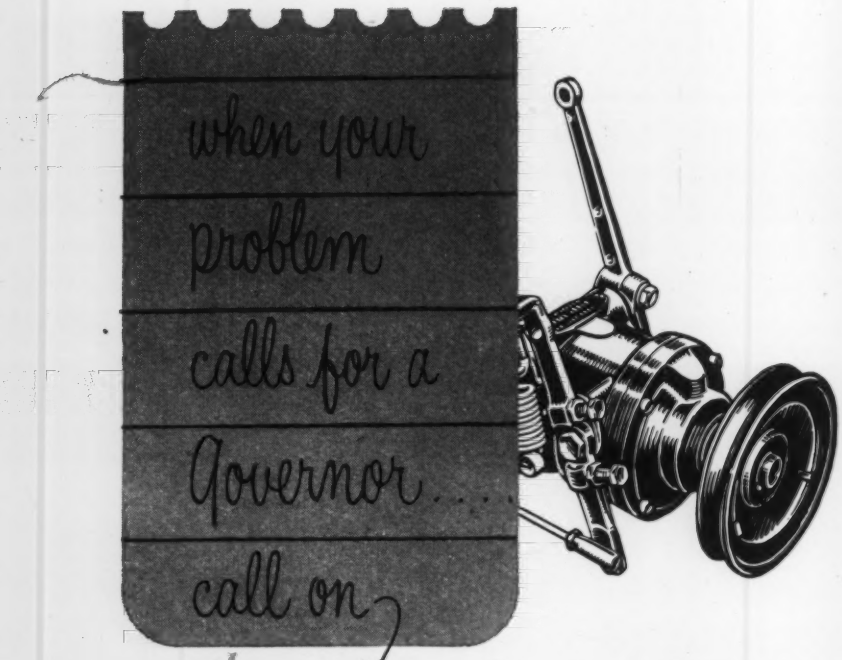
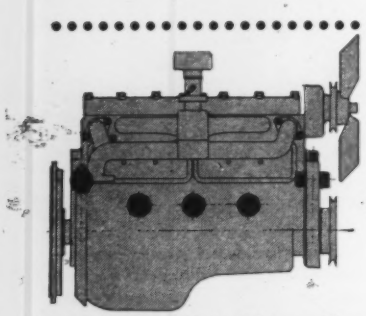
Synthane-one of industry's unseen essentials

SYNTHANE
S
LAMINATED PLASTICS



PIERCE

40 years specialization in the speed control field



Pierce Designs Make it Easy to Plan for Efficient Governor Installation: As shown in the above diagram there are a number of places on your engine where you can provide drive access for a Pierce Governor: Top, front or rear of timing gear . . . or at various locations connecting directly to camshaft. Pierce builds a wide variety of mounting types and drives . . . governor assemblies to cover every engine speed control problem.

Pierce Centrifugal Governors are in daily use for accurate, dependable engine speed control wherever wheels turn. More than 4,000 different governor assemblies have been designed and built by Pierce to meet exacting problems and applications encountered by engine builders. Pierce Governors are standard on many of America's finest engines.

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Ask for the new Pierce Brochure . . . "40 Years of Manufacturing Precision Controls."

PIERCE THE MARK OF QUALITY

THE PIERCE GOVERNOR CO., INC.
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also built by PIERCE

SISSON Chokes — Automatic Carburetor Chokes, original equipment or replacement.

Aircraft Accessories — Overspeed Governors and Fuel Controls for turbojet engines.

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Design Abstracts

line in overcoming resistance and reactance drops.

In an ac circuit the transient current is limited chiefly by the reactance. That is, the current creates magnetic fields linking the circuit and these fields induce voltages which oppose the current flow. In this process, energy is transferred from the electric circuit to the magnetic field as the current rises and is returned to the electric circuit as the current falls, in each cycle of operation.

In a balanced three-phase circuit the double-frequency power components of the three phases are displaced 120 electrical degrees in time phase, giving a zero sum at each instant. The only net power flowing in the combined circuits is the I^2R loss, or active power, divided equally among the individual phases.

Evaluating Energy Flow: You have seen that there can be no net power flow across an air-gap space, unless and until a store of magnetic energy is first created in the space to act as a carrier for the energy flow. This is likewise true of radio-broadcasting, as mentioned earlier. The numbers are different but nature's process for transferring energy across a 20-mil air gap is the same as for a space of 1000 miles. In the small air gap of a motor however the proximity of iron and copper (with permeability and conductivity vastly greater than that of free space) leads to much greater energy densities and correspondingly greater rates of power flow than for radio waves.

There is a well-known theorem in physics, derived from Maxwell's equations that states:

> The flow of electromagnetic energy through (penetrating) any surface is equal to the integral of the Poynting vector $EH \sin \alpha$ over the surface where E and H are the electric and magnetic-field intensities in the plane of the surface, and α is the angle between their directions. The direction of the vector is at right angles to both E and H.

This theorem describes the flow of energy across the air gap of a motor, as well as the propagation

NEW CONCEPTS IN FINE-PITCH GEAR SUPPLY!

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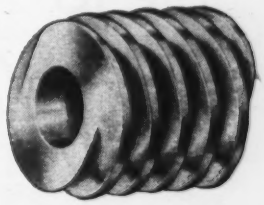
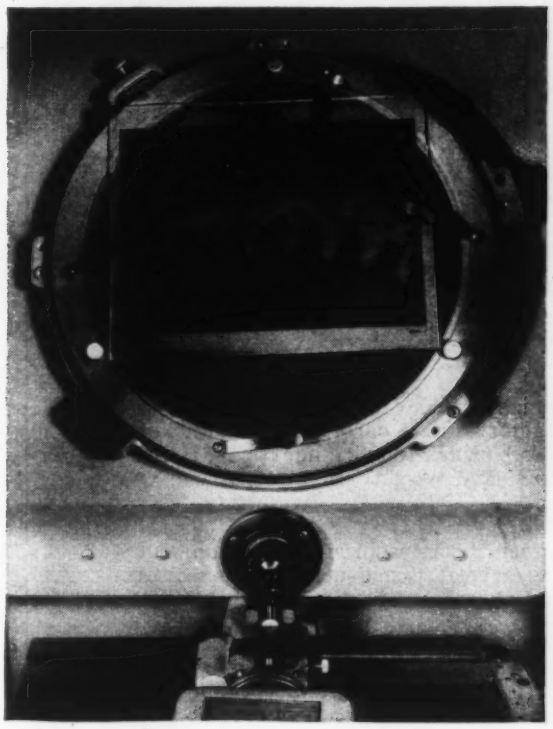
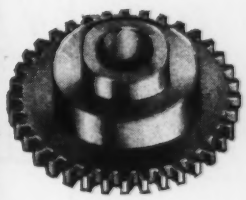
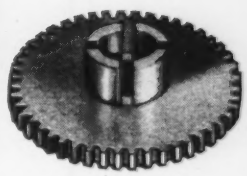


GEARS WITH A PEDIGREE







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Design Abstracts

of radio waves through space. Evaluation of these energy flows enables the process of energy transference across the air gap to be clearly seen. The power supply system serves as a reservoir into which the magnetic field energy is alternately delivered and received each quarter cycle. In free space the electrostatic field energy serves this purpose. In the motor however the magnetic-field strengths are multiplied many fold by the proximity of the power currents and the iron, making their energy vastly exceed that of the associated electrostatic fields.

Designers require exact values. To this end they rely on equivalent-circuit calculations. They will find the energy method of analysis provides a key to the calculation of the finer points of motor performance, as well as a deeper understanding of its behavior and operating characteristics.

From an article entitled "Energy Flow in Induction-Machines" appearing in the General Electric Review for March 1953.

Approach to Automation

By C. F. Hautau

Hautau Engineering Co.
Detroit, Mich.

AUTOMATION is the general name given to the study and development of machines for making products on an automatic basis. Although the word has not yet achieved the dignity of being listed in the dictionary, it already has developed a number of meanings in industry. The production departments in many of the plants where the automation engineers are at work, designate the group as one which is going to solve all production problems without knowing what the problems are.

Since the automation engineers are assayed at that kind of value by their fellow workers, it is only normal that they adopt a definite aggressive philosophy, or shall we say, they become possessed with a slight amount of over-confidence. It is necessary that they do this, for they must be ready to be at-

tacked by all of the experts, who in almost fiendish glee, try to point out the fallacies of any proposal that they make to change an operating system or a machine.

Basic Philosophy: Primarily, the goal for all automation is to eliminate all manpower from a plant or production line, and develop an automatic factory. So far this goal hasn't been reached, but we can go a long way in this direction when we eliminate all forms of intermachine storage of parts and sections. At present, machine tools can efficiently carry out the actual processing of parts, but these must be moved from processing machine to processing machine. In addition, a bank of the parts usually must be provided between the machines to take care of the dissimilar operational rates of each of the different units.

Many modern machine tools or processing units are provided with satisfactory feeding devices for hand operation. They usually do not have the type of device that will properly index, orient and position the piece as it comes from the preceding machine. This must be provided by the automation expert.

In most cases, the study and the development of an automation project is not set up for a possible 3 to 5 per cent saving in cost, but to reduce cost by one-half or more.

We must remember too, that the process of automation also includes many by-product results, which cannot be included in the actual cost figures of the parts being produced. For example, when a line is completely automated, it is possible to reduce the tolerance spread of mating parts, because an automated line must have built into it automatic inspection devices at each of the processing stations. This means that you do not have the human factors of personal inspection that quite often are affected by the inspector having sick children at home or having had a tough night previously.

Process Evaluation: After it has been decided that a line or process

(*Continued on Page* 316)

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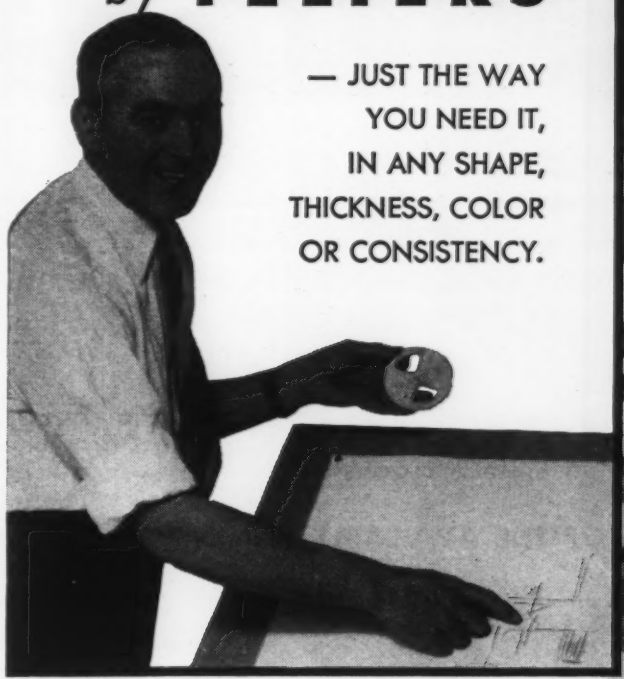

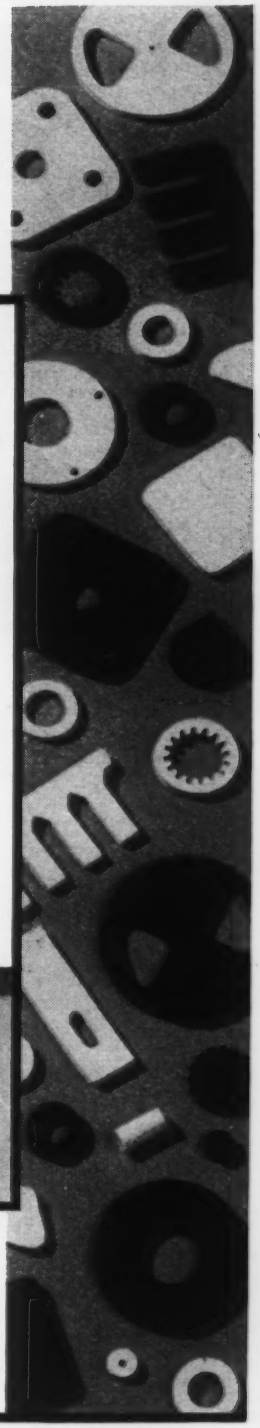

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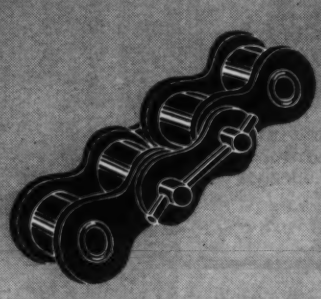
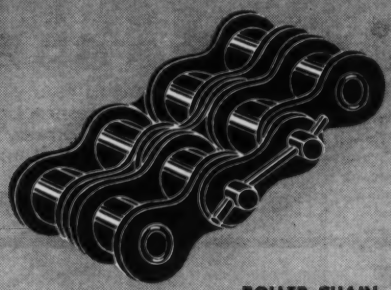
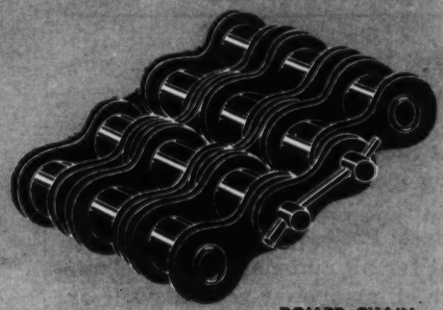


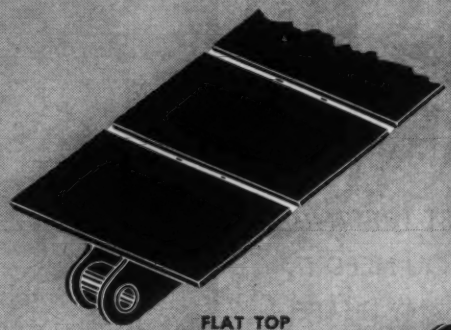
ROLLER CHAIN
SINGLE STRAND



ROLLER CHAIN
DOUBLE STRAND

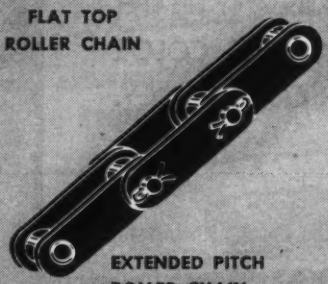


ROLLER CHAIN
TRIPLE STRAND

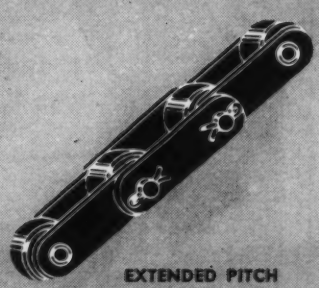


FLAT TOP
ROLLER CHAIN

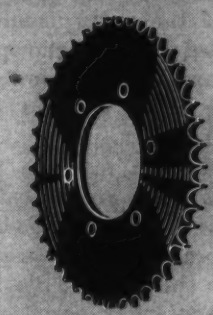
IT'S A FACT-



EXTENDED PITCH
ROLLER CHAIN
STANDARD DIAMETER ROLLERS

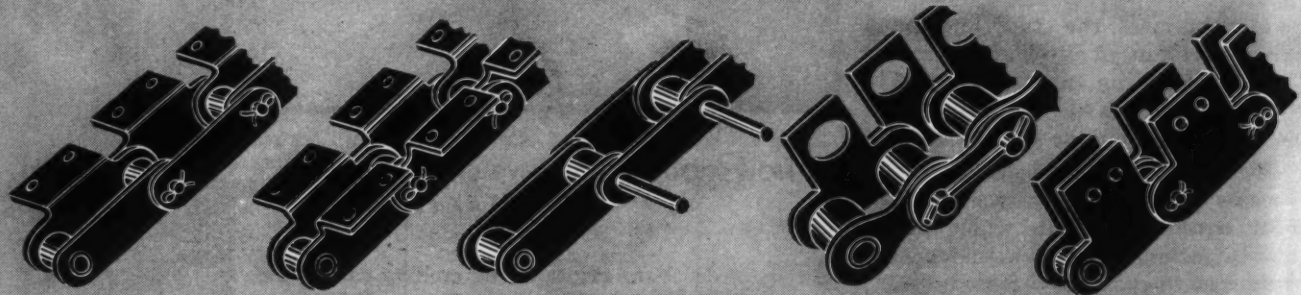


EXTENDED PITCH
ROLLER CHAIN
LARGE DIAMETER ROLLERS



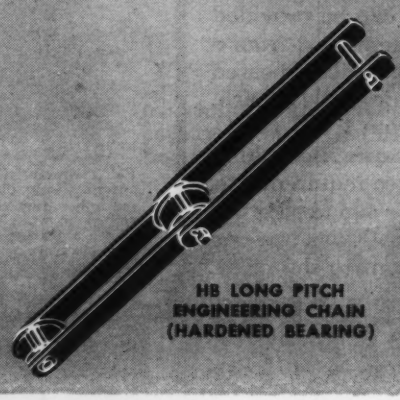
ROLLER CHAIN SPROCKET
STYLE A

SOME OF THE AVAILABLE UNION ROLLER CHAIN ATTACHMENTS

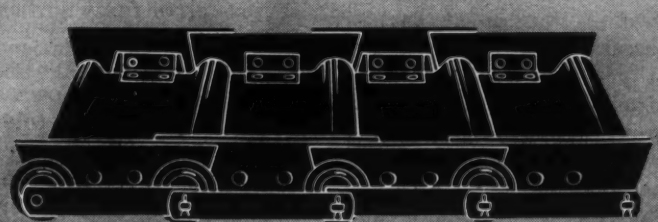


A-2 K-2 D-3 M-1 MM-2

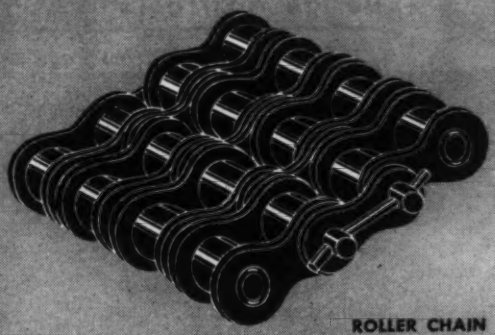
OTHER TYPICAL UNION CHAIN PRODUCTS



HB LONG PITCH
ENGINEERING CHAIN
(HARDENED BEARING)

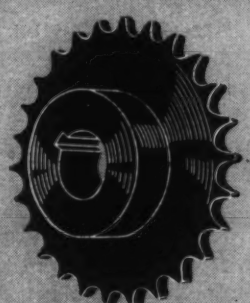


APRON CONVEYOR STYLE B

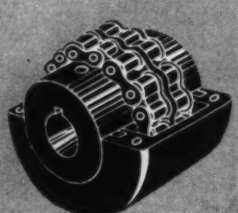


ROLLER CHAIN
QUADRUPLE STRAND

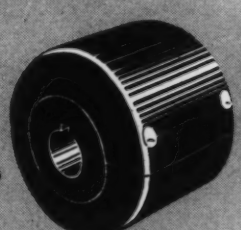
THERE ARE 381 ROLLER CHAINS AND ROLLER CHAIN ATTACHMENTS IN OUR CATALOG A-3....



ROLLER CHAIN SPROCKET
STYLE B



ROLLER CHAIN
FLEXIBLE COUPLING
(COVER OPEN)



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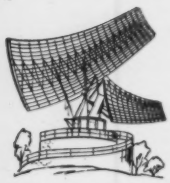

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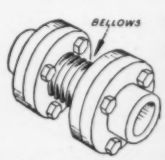

Typical Application

TYPICAL APPLICATIONS: For such applications, as vhf, uhf, or high voltage—high temperature insulator forms, heat-resistant linings, oil and fire-wall seals, gaskets, valve discs or seats, packings, flexible bellows, diaphragms, slot liners, heat sealer jaws and dough rollers. Let our engineers fit "JOHN CRANE" TEFLON to your specific needs.

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Design Abstracts

(*Continued from Page* 313)

is subject to improvement by making it automatic in operation, it is necessary to study the project along the lines of what can be called the antithesis approach, rather than along the parallel approach. This is actually the study of each operation to develop some other way of processing, rather than along the line of following the present practice. When thinking is completely divorced from present practice, expansion of ideas in many channels may result in shortcuts and simplified methods of procedure.

The basic plan of present-day production is to connect together all operations in a single line. Conveyors move the parts from machine to machine, with the least amount of operator attention. This type of plan always results in a storage of parts between each processing station or machine along the line.

The aim of an automated system is to completely control or hold the individual part, as it is passed from processing station to processing station, so that all of the positioning feeding and inspecting, is done on the basis of an individual part. The reasoning behind this approach is that, by including in the machine an inspection of the individual piece, it is impossible to run a large number of parts which are off specification and which later must be scrapped. When a machine is completely automated, an improperly made part will stop the process or eject the part, without affecting a large number of the pieces being processed.

Production Application: Unfortunately, most of the publicity given to automation and automated systems has been on the basis of those lines which produced millions of parts per year. It is natural that the operator of a small plant believes that automation is only valuable in the high-production field. It follows that he probably pays very little attention to the basic philosophy behind automation and consequently does not realize that it can be applied with equal success to lines which produce only a few

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Design Abstracts

hundred parts of one kind in a year.

The idea of using a special machine or of automating a line of machines is that kind of thinking which, when applied to the problem, searches for a solution to produce a better product as well as to manufacture a product at lower cost. It is true that the greatest saving in dollars can be made on high-production systems. However, when thinking of any processing in a plant on the basis of "why do I do this particular operation?", thoughts are being projected in the proper direction for making an automatic system.

From a paper entitled "Method of Automation" presented at the Tenth Annual Machine Design Conference of the Cleveland Engineering Society in Cleveland, O., February 1953.

The H Factor in Design

By Clifford Seitz

Head, Program Branch
U. S. Navy Special Devices Center

IF WE examined the modern hammer, I think we would find its weight, handle length and diameter, and other dimensions are fairly standard. If we then undertook a study to determine the "best" dimensions for a hammer, we would probably find the present hammer just about what it should be.

There's no doubt about it—the hammer is well designed. But how did it happen? It all happened a long time ago when a man designed the first hammer for his own use; later he made hammers for other men, and then he discovered that the hammer that suited him wasn't acceptable to others. Through a process of trial and error, through experience, and by evolution, a hammer suitable to the needs of many men was designed. This process of design by evolution can apparently produce a reasonably well-designed product, but it inevitably costs a lot in time.

The H Factor: We are obviously

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eager to telescope the evolutionary process, and so some people have concerned themselves with the human or H factor in engineering design. Some of us know that considering the H factor helps us to design much better equipment. We feel that the human factor is so important that we want our fellow engineers also to use this knowledge. But somehow and for some reason most of them don't. We want to point out what we think stops engineers from systematically considering the human factor and show how these barriers can be removed.

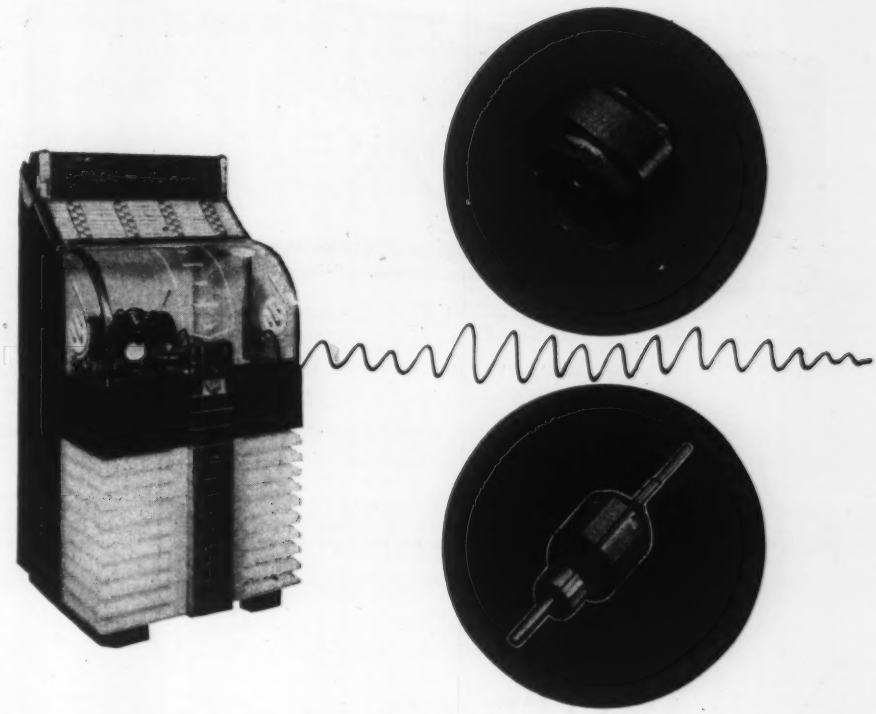
H Factor Obstacles

There are many reasons why the human factor is not systematically used. The most important seems to be that, as in the case of the first hammer, the human factor is considered and is thought of as common sense.

After all, engineers are men and know something about other men. They, of course, recognize that men are different—that some are taller, stronger, and quicker than others—but they seldom realize how big these differences are and how many and subtle they can be. They see the differences in terms of their experiences with men much like themselves, not in terms of the universe of men. The hammer suits them—it may suit their engineering friends—but it takes a century or more before it will suit the universe.

The common-sense variety of human engineering is handicapped, in addition, because it is casual: there is no preplanning—no systematic study of goals. It's a matter of chance if the human factor is accounted for, and the results are seldom predictable and generalizable.

It's apparent the engineers need more human engineering help, but it's also clear that they won't buy help they see no need for. The problem therefore is to make it possible for engineers to know more about the human factor; to appreciate the wide range and reserve of performance; and to recognize that elusive factors such as personality and morale can make



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EMC and CYCLOHM fractional h. p. motors are used by many manufacturers of coin operated devices as well as hundreds of other applications—business machines, sewing machines, mixers, fans, blowers, radar, jet aircraft, tape recorders, portable tools, appliances and others. Whatever your application, if you use fractional h. p. motors or motor parts sets, check your requirements with Howard today. Your inquiry will be given prompt attention.

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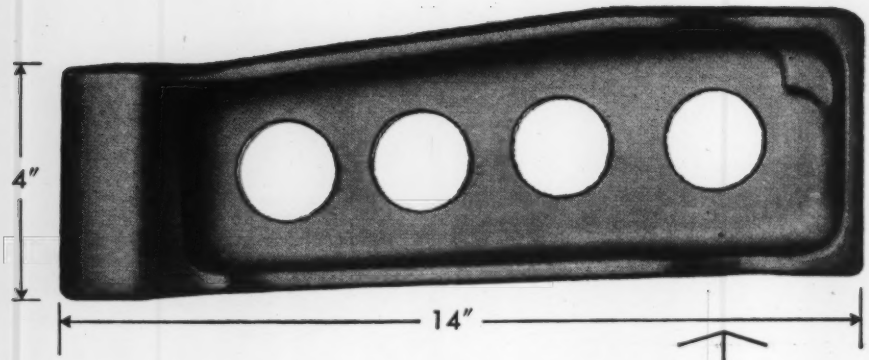

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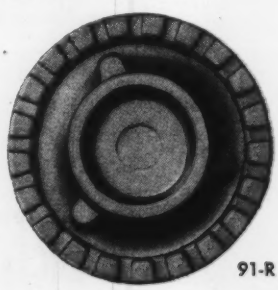

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91-R

Design Abstracts

a big difference, or, for example, that in a man-machine system the errors contributed by each accumulate as the sum of the squares of the errors.

Progressive Programs: Our discussion seems to boil down to just one thing—engineers need more knowledge about the human factor without at the same time becoming human engineers. We think that there are short-and-long-range plans that will meet this goal. The short-range plan requires that the organizations and men who recognize the importance of the human factor insist on writing human engineering requirements into specifications. If such contracts are written, the contractor can afford to employ human engineering talent and orient his engineers to the human factor in engineering design. The staff will have an opportunity to learn through exposure, and the product should be more competitive.

The long-range plan is based on the assumption that human engineering is a subject relevant to engineering and psychological training. We propose, therefore, that human engineering become a subject for the engineering and psychology curriculum, that graduate courses be offered, and that scholarships and awards be made to engineers and human engineers in support of additional training and in recognition of their contribution to human engineering. We also believe that industry should support an exchange program. Young engineers interested in the human factor should be sent to a university or an industrial human engineering concern for a year, and in exchange a human engineer should be farmed out to industry.

The use of the industrial internship or planned program for the growth of staff is common practice in many companies and has inestimable benefits to employer and employee alike.

From a paper entitled "The H Factor in Engineering Design" presented at the Air Safety Seminar of the Flight Safety Foundation, Inc. in Bermuda and reprinted in the Aeronautical Engineering Review for March 1953.

Why you can *lower inspection costs* with a Kodak Conju-Gage Gear Checker

Why the composite check

The composite check recommended in American Standard B6.11-1951 tests gears functionally by running the gear against a master of known accuracy. The resulting displacement shows at once the cumulative effect of as many as six types of error—eliminates time-consuming checks for each individual error. The check is rapid and conclusive.

Why the Kodak Conju-Gage Gear Checker

To meet today's tolerance requirements, the Kodak Conju-Gage Gear Checker uses a master made with a new order of precision. This is the Kodak Conju-Gage Worm Section, produced by thread grinding under control of a precision lead screw.

The accuracy inherent in this method means every right gear is passed by the worm section, reducing rejection losses. The transverse curvature produced by this method provides a master that can be used to check any gear of like pitch and pressure angle, regardless of helix.

Not only can a single worm section be used in place of a number of circular masters, but such a worm section can be reground to specification as often as necessary—at a fraction of replacement cost. It is easily checked for accuracy by familiar toolroom procedures.

You can find out more about the economies possible through Kodak Conju-Gage Instrumentation by sending for a copy of the booklet, "Kodak Conju-Gage Gear Testing Principle." Write to:

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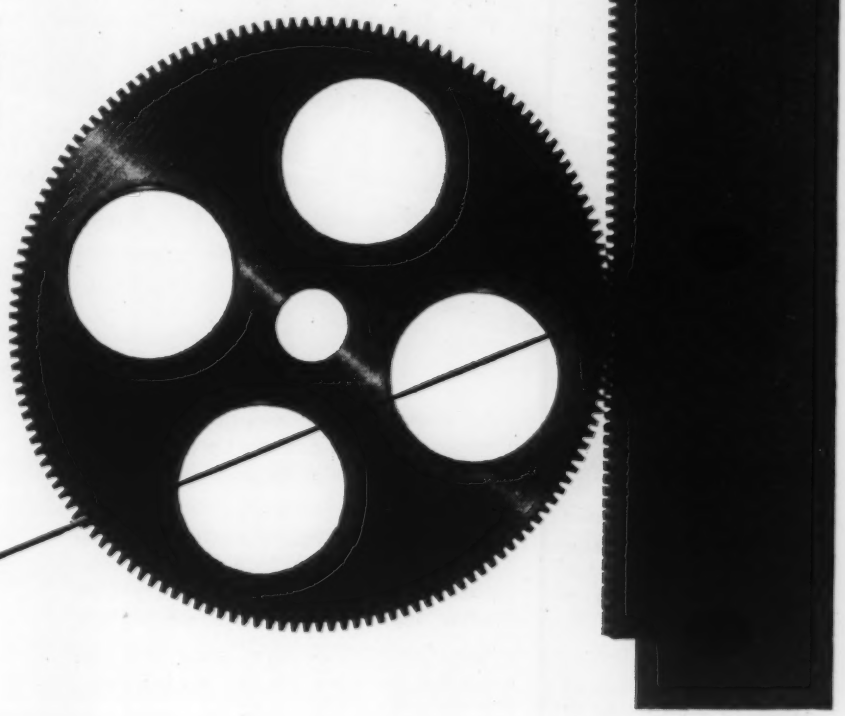

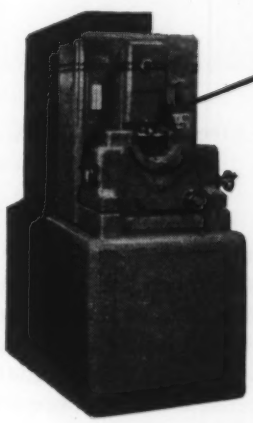

The Kodak Conju-Gage Gear Checker automatically records the composite effects of runout, base pitch error, tooth thickness variations, profile error, lead error, and lateral runout. Illustrated is the Kodak Conju-Gage Gear Checker, Model 4U, for gears up to 4⅛" pitch diameter. Larger and smaller models are also available.

CONJU-GAGE INSTRUMENTATION

... a new way to check gear precision in action

To inspect all kinds of complex parts on a bright screen, Kodak also makes two highly versatile contour projectors.

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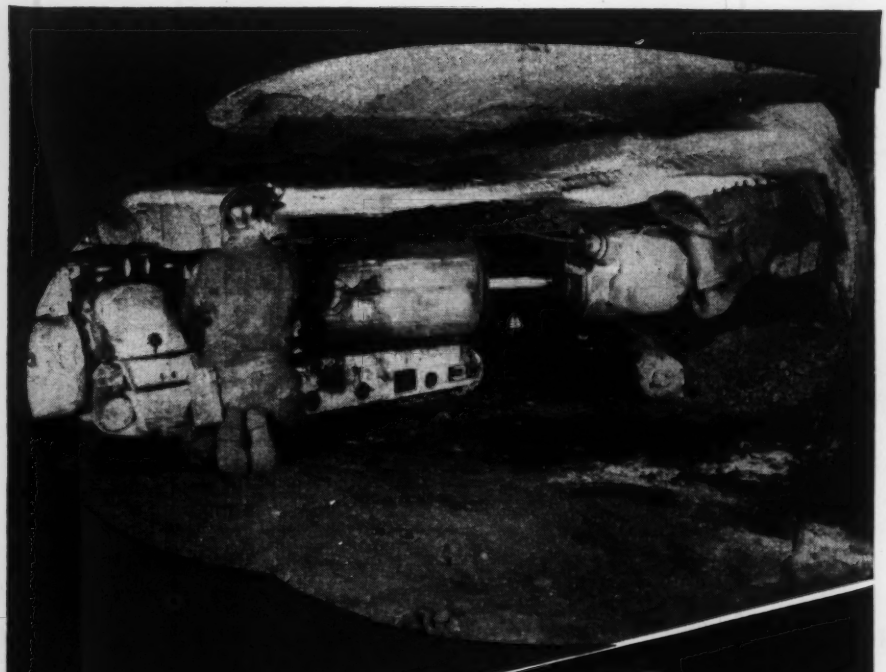

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Joy Manufacturing Company's continuous mining machines can dig up to 600 tons of coal in two shifts and load it into shuttle cars.

They are really rugged machines that require the ultimate in high capacity, compact, long life drives for the rotary drum cutter heads and conveyor mechanisms.

Five Cone-Drive worm gear sets per machine were specified by Joy engineers to meet these requirements.

The 65-hp. main drive for the cutter head has two 7-in. center distance, 5/1 gear sets. Three 3.577-in. C.D., 6/1 ratio gear sets drive the conveyors.

More and More mining equipment designers and users are turning to Cone-Drive standard gear sets and speed reducers for greater capacity and longer life in less space at lower cost.

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CONE-DRIVE GEARS

Division Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

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New Machines

Domestic

Small Ranges: Two models measuring 24 and 36 in. wide. Have pushbutton controls; calrod, enclosed sheath type oven and surface units; full-size ovens; automatic oven timers; high backsplash panels with fluorescent lights and appliance outlets. Ovens measure 21 in. wide, 18 in. deep and 15 in. high; feature removable no-stain vents, two lock-stop shelves adjustable to 12 positions, porcelain enamel broiler pan and chrome broiler rack, removable broil and bake units, enclosed heating elements, front-serviced terminals, cycling light to indicate when the oven is at correct cooking temperature, and counter-balanced oven door. *Major Appliance Div., General Electric Co., Louisville, Ky.*

Portable Typewriter: Keyboard includes common arithmetical signs and business symbols. Features balanced segment shift; "See-Set" margins; single, double and triple spacing; standard spaced keyboard; finger form keys; automatic ribbon reverse and color styling for eye comfort. Base of carrying case can serve as a desk. *Underwood Corp., New York, N. Y.*

Electric Range: Model RD-17 is controlled by illuminated pushbuttons. Has single oven with 4700 cu in. of space, a "super calrod" surface unit which is 30 per cent more efficient than former units, and a plug-in "golden bake" heating unit that circles the oven floor. Has 220-v outlet on control panel for an automatic deepwell french fryer, which is an optional accessory. Includes oven and surface unit pilot lights, two-speed electric time measure, full length fluorescent light, aluminum broiler, "golden fryer" unit receptacle, timed appliance outlet, oven light, three storage drawers, roaster pan, and a raiseable calrod thrift

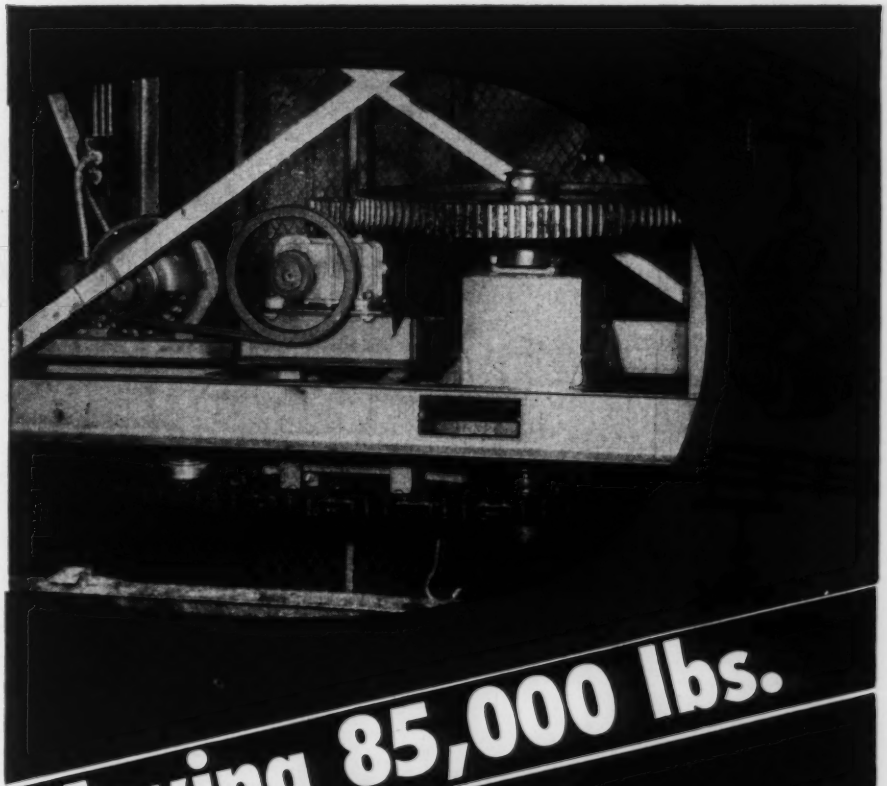
cooker unit. *Hotpoint Co., Chicago, Ill.*

Materials Handling

Universal Loader: Available in 2500, 4000 and 6000-lb capacities; mounts on Case, Minneapolis-Moline, Shepherd and Oliver industrial tractors. Primarily for outside yard materials handling. Has large, high-flotation pneumatic tires; high underclearance and axle oscillation on industrial tractors; low center of gravity. Sufficient power and weight for maximum traction permit operation in mud, snow and on uneven ground. Combines a tilting tower with ten handling attachments. Tower tilts 20 degrees forward and 9 degrees to the rear of center. Lifting height of largest standard model is 100 in.; higher lifts optional. *Baker-Lull Mfg. Co., Minneapolis, Minn.*

Portable Winch: Gypsiwinch has capstan drum for critical control of loads. Standard models equipped with either electric or gasoline power units ranging from ¾ to 7½ hp. Power units are instantly reversible and operated by a lever control. Mechanical efficiency of more than 95 per cent is obtained on reduction units. Capstan principle permits taking up and stopping heavy loads very slowly, with no stress on rigging or equipment. Winch also available in combination with cable drum, permitting use of either hoisting cable or manila line. Base dimensions range from 12 by 32 in. on smallest model to 12 by 42 in. on largest. *St. Anthony Machine Products Co., Minneapolis, Minn.*

Hydraulic Lift Hand Trucks: In lifting capacities from 500 to 3000 lb; lifting heights from 36 to 98 in. Manual lift machines feature Varilift hydraulic system which increases the speed of some operations by as much as 400 per cent. Electric models are powered by either one or two self-contained auto batteries or are operated from power lines. Two-wheel Shop Caddy hand truck with hydraulic pallet lift is available in five models with load capacities of 500 lb



Moving 85,000 lbs. on a conveyor with a 3" CONE-DRIVE

This 3-hp. drive unit, made by General Conveyors Corp., Van Dyke, Michigan, for a 1500-ft. long monorail conveyor, carries half the load of moving 170,000 pounds of V-8 automotive engines hour after hour, month in and month out. It's the kind of modern installation that demands continuous trouble-free operation.

That's why General Conveyors engineers specified standard 3-in. center distance, 15 to 1 ratio, Cone-Drive speed reducers for each of the two synchronized drives.

The ruggedness and maintenance-free long wear life of standard Cone-Drive reducers make them 'naturals' for conveyor drives. In addition, original units or replacement parts for these units can be delivered off-the-shelf for any emergencies.

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SALES VALUE is only one of many advantages added to your product when you use Phillips Screws. These screws also save money, work, time. They eliminate driver skids, damaged parts and split screw heads. They cut driving time up to 50%. And they set up tighter having a maximum strength of head due to their design. For best results, choose Phillips Wood, Machine, Tapping Screws or "Sems."

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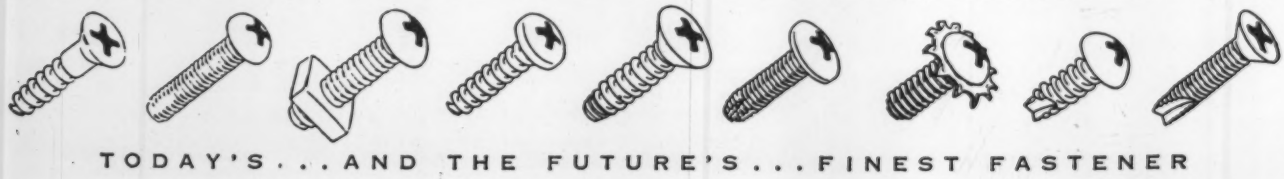

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Severest weather conditions have not affected in any way the Slo-Speed motor driving our 250-ft. outdoor inclined belt conveyor which is in constant use up to 14 hours per day, reports Gene Herbst, Vice-President, Central Concrete Co., St. Louis. We attribute this uninterrupted service to rugged construction and Sterling's protected drip-proof design.

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Agitators	**Dryers**	**Presses**
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and lifting heights of 36 and 54 in. *Allied Mfg. & Sales Co., Chicago, Ill.*

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Grinder: Model 418 for fast precision traverse or plunge cylindrical grinding of small parts. Features Pope wheel spindle, wheel slide rapid retraction and slide base proportioned and constructed for rigidity and accuracy, automatic starting and stopping of headstock and table traverse, semi-automatic lubrication. Grinding wheel speeds are 1772 and 2067 rpm; headstock work speeds are 153 to 940 rpm. Maximum grinding diameter, 4 in. Maximum distance between work centers, 18 in. Floor space required, 43½ by 79¼ in. *Van Norman Co., Springfield, Mass.*

Welder: Redesigned 300-amp unit. Features stepless current selection from 40 to 375 amps. Applications include light-duty, low-current sheet-metal work as well as heavier-duty, high-current industrial jobs. Has large scale and finely threaded screw adjustment to facilitate current selection. Accommodates electrodes from 3/32 to ¼-in. diameter; switch enables quick change from high to low range. Arc stabilizing capacitors eliminate popouts. Silicone insulation provides protection against high temperature coil failure. Size, 36 in. high, 21 in. diameter; weight, approximately 328 lb. *General Electric Co., Schenectady, N. Y.*

Power Rod Parter: For cutting or "parting off" rods and bars without burr and distortion. Accommodates rods 1/16 to ⅝-in. diameter. Has motor-driven flywheel drive which operates at 180 strokes per minute. Ejectomatic gage allows gaging, ejecting and cutting to be performed in a single working cy-

(*Continued on Page* 330)

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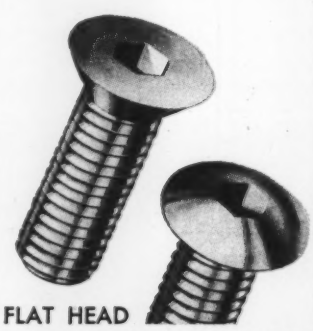

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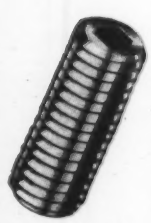

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This unique head design saves assembly time

Only P-K offers the Size-Mark and Gear Grip on Socket Head Cap Screws.

The size is clearly incised on the head, can be seen at a glance. It saves time and wasted screws when sizes get mixed up, prevents errors by "green" workers, helps veterans, also, to speed assembly. Maintenance men like it — it aids them in reassembling. Gear Grip prevents slips, speeds work, even when fingers are oily.

Since assembly expense is a sizable percentage of total production costs (in some products as high as 75%), fastening operations are any manufacturer's primary target for cost reduction.

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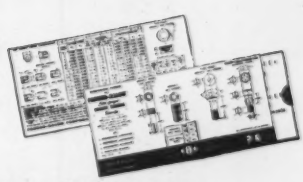

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WINSMITH speed reducers

Jetting ready stream of dry-cold, hard ice flakes at the touch of a button—kind of magic this Instant Ice Machine was made for. That's its job. Hospitals, restaurants, hotels, dairies, meat packers and super markets count on it. And well they may — for Liquid Freeze Corporation, manufacturer of Instant Ice Machines, has been extremely careful in the selection of sturdy, long-lived components for tough day-in, day-out performance.

Centered in the drive mechanism powering the stainless steel blades which flake the ice, is a Winsmith Speed Reducer, Worm Gear Model 3 1/2 B, with an input speed of 2150 rpm and an output speed of 59½ rpm. "Chosen for adaptability, sound engineering design and construction . . . we have found it rugged and dependable in every way," says Liquid Freeze Corporation.

Reasons such as these have led manufacturers to look to Winsmith when they are looking for speed reducers. With fully standardized differential, worm gear, helical gear and worm-helical units — the Winsmith line is the most complete within its range of 1/100 to 85 hp and 1.1:1 to 50,000:1 reduction ratios.

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New Machines

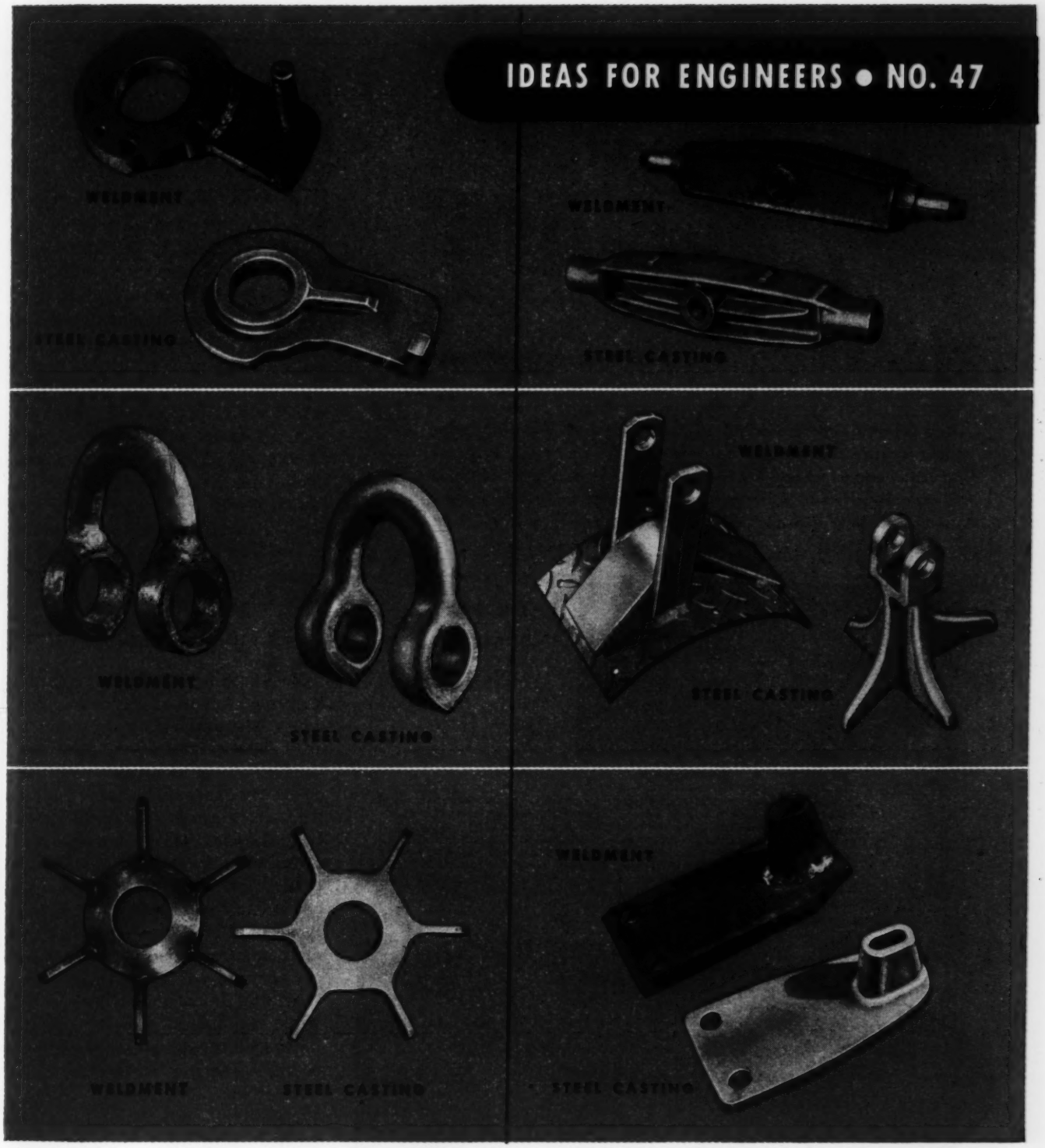
(*Continued from Page 327*)

cle. Material can be cut as fast as the operator can feed stock through cutting heads and engage foot clutch. Operating height, 40 in.; floor space required, 17 by 28 in. Special heads for cutting square, rectangular, hexagonal and other shapes can be supplied. *O'Neil-Irwin Mfg. Co., Lake City, Minn.*

Die Casting Machine: Model IMP/96 has impact type injection system—the piston area for injection is much larger than the area for piston return, which results in high-speed injection with no cushioning effect from the air trapped underneath the piston. Features fast chilling, high cycling and automatic ejection of finished parts. Production runs of 800 to 1000 shots per hour can be obtained. Unit uses small prefabricated die blocks which are completely machined except for the cavity itself. Requires 12 by 36 in. of floor space; weighs 470 lb. *DCMT Sales Corp., New York, N. Y.*

Punch Presses: For drawing, forming and other metal operations requiring slow, powerful strokes. Have stub-tooth back gears; speed range from 40 to 100 strokes per minute. Speed may be varied by changing size of motor drive pulley. Single-trip mechanism requires that ram be individually triggered for each stroke. Stroke can be converted to continuous motion by removal of one screw. May be fed by hand or automatically. Back gearing is available on three presses, the 4-ton standard, 4-ton deep throat and 7½-ton models. *Benchmaster Mfg. Co., Gardena, Calif.*

Semiautomatic Bender: Small unit for serpentine coil bending. Designed especially to fit production line needs. Equipped with single control lever, stationary bending form, rotating wiping shoe and semicircular table to maintain long coils in horizontal position during sweep of bending cycle. First bend is completed in conventional manner, then stock is rotated 180 degrees before clamping for succeeding bends. Will handle tubing up to 1-in. OD, 16-gage and 5 ft in length. Production averages



These are a few of many smaller parts which have been *redesigned to steel castings.* They will suggest ways you can improve some of your products . . . probably with a reduction in costs.

The results shown here were obtained through cooperation of the steel foundry with the manufacturer's engineering department. Perhaps your steel foundry can be equally helpful to you.

STEEL FOUNDERS' SOCIETY OF AMERICA

920 Midland Building — Cleveland 15, Ohio

Design and Build With Steel Castings

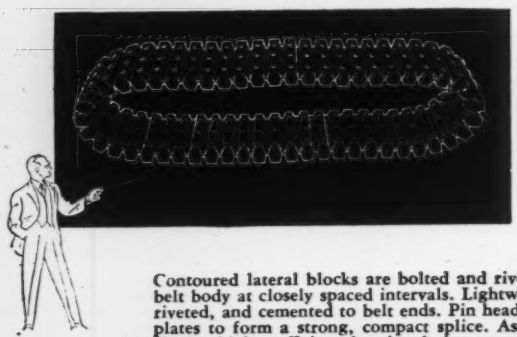
51 YEARS OF SERVICE TO INDUSTRY

Look particularly to the belt on a variable-speed transmission

makes sense

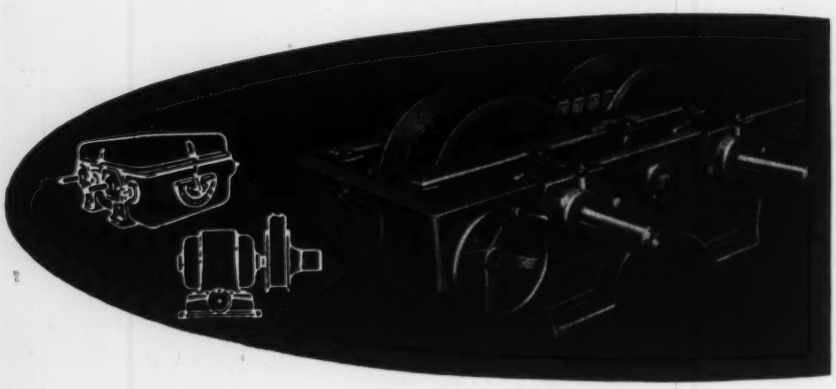
to an engineer

In a variable-speed transmission, the V-Belt drive operating principle is proved . . . and, *the belt is its "heart"*. That's why belt construction and dependability is of vital importance. As you consider a variable-speed drive for a production machine, we ask you to compare Lewellen, point for point, *and look particularly to the belt.*



THE BELT BUILT TO "TAKE IT"

Contoured lateral blocks are bolted and riveted to an impregnated, plied belt body at closely spaced intervals. Lightweight splice plates are pinned, riveted, and cemented to belt ends. Pin heads interlock with mating splice plates to form a strong, compact splice. Assembled belt is machined and single, high-coefficient fractional tips are cemented and pinned to block ends. The result: a highly flexible, laterally rigid, lengthwise resilient V-Belt that provides a wide range of speed variation, infinitely adjustable speed settings, highly uniform speed regulation and wholly reliable performance under all load conditions.



Open or enclosed—horizontal or vertical Transmissions in sizes from fractional to 60 h. p. . . . Variable-Speed Motor Pulleys . . . Automatic Controls . . . More than 50 years in this specialized field.

LEWELLEN

VARIABLE SPEED CONTROL AT ITS BEST

MANUFACTURED BY LEWELLEN MANUFACTURING COMPANY, COLUMBUS, INDIANA

New Machines

450 bends per hour. Die height from floor is 35 in.; overall dimensions of base are 74½ by 15 in. *Pines Engineering Co. Inc., Aurora, Ill.*

Up-Feed Mechanism: Provides automatic precision up-feed in selected increments throughout shaving cycle. Returns automatically to proper backlash position for loading and unloading at the end of the cycle. Either conventional or diagonal shaving can be done. Shaving diagonally can include several cutting strokes each with its own increment of up-feed as well as one or more idling strokes. Cycle time has been decreased because of rapid up-feed and increased cycling speed. Increments of up-feed may be constant or varied. *National Broach & Machine Co., Detroit, Mich.*

Office Equipment

Bookkeeping Machine: Has 46-key, touch-operated keyboard. Produces, simultaneously or individually, sales and income analyses; vendors accounts payable with purchase and expense analyses; payroll with cost records and minimum labor analysis. Makes multiple records with mechanical proof for every entry, instantly computes account balances and automatically accumulates accounting control figures. Operation assures proof of posting. Carriage locks and tabulator is rendered inoperative while a numeral key is partially depressed. Locking action enforces correct register totals, decimal tabulations and posting of balances. *Remington Rand Inc., New York, N. Y.*

Adding Machine: Adds and prints figures automatically as they are entered on the "Live" keyboard; motor bar need not be depressed. Claims to eliminate 50 per cent of all hand motion. *National Cash Register Co., Dayton, O.*

Paper Punch: Electric powered, foot-actuated Model 116-EP punches 20,000 sheets of average stock per hour. Does not require special setup tools, wiring or operator training. To set sheets in proper position, operator adjusts

PUMPS

for Home, Defense & Industry!

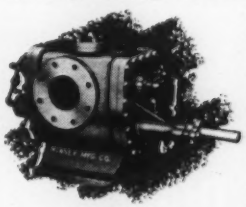
What do you need . . . Hydraulic controls for a bomber, a helicopter, a guided missile or for a machine tool, piece of construction equipment, lift truck or paper machine? A better water supply for your home or pumps for an entire irrigation project? Or, perhaps, you need high vacuum pumping facilities or a pump that will handle paraffin, tar or syrup. Whatever it may be, you'll find pretty close to an ideal answer here . . .

HYDRECO GEAR TYPE PUMPS

Reversible and non-reversible. Gear type pumps in exclusive FOUR-BOLT design . . . capacities from .5 to 130 gpm and operating pressures to 1500 psi . . . flange or foot mounted . . . furnished with keyed shaft with spline shafts optional. Also dual and tandem models.

KINNEY LIQUID HANDLING PUMPS

A complete range of sizes in Rotating Plunger and Herringbone Gear Pumps to handle light or heavy liquids, sludges, slurries or viscous substances. Available in plain or steam jacketed models and built of special corrosion resistant metals where desired.

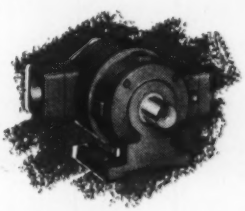


KINNEY VACUUM PUMPS

Single stage models to produce absolute pressure readings of 10 microns (.01 mm Hg.) . . . compound pumps producing readings of .2 microns (.0002 mm Hg.) or better. These Kinney High Vacuum Pumps are available in sizes for laboratory as well as high production use.

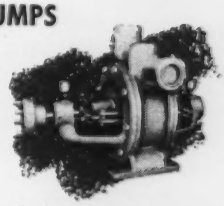
DUDCO DUAL VANE TYPE PUMPS

DUDCO Pumps provide a broad range of sizes with capacities to 120 gpm and pressures to 2000 psi. Also available in multiple units operating from a single drive. Hydraulic motors with starting torque outputs to 14,000 lb. in. at 2000 psi.



AURORA CENTRIFUGAL & TURBINE PUMPS

Deep well, sump, drainage and condensation return units, household water systems. Industrial low and high pressure liquid handling pumps. Direct motor and countershaft driven horizontal and vertical models. Capacities 3 to 7500 gpm.

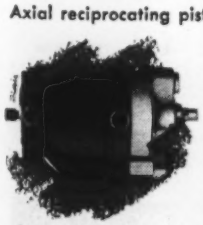


THE NEW YORK AIR BRAKE COMPANY

230 PARK AVENUE • NEW YORK 17, N.Y.

STRATOPOWER PISTON TYPE PUMPS

Axial reciprocating piston type . . . constant or variable delivery with capacities of .25 to 10 gpm at nominal speeds of 1500 rpm with maximum of 4500 rpm . . . working pressures to 3000 psi . . . direct engine and individual electric motor driven models.



Write—

For detailed information on the type of pump in which you are interested.

THE NEW YORK AIR BRAKE COMPANY
230 Park Ave., Dept. MD, New York 17, N.Y.

Gentlemen: Kindly send additional information on the pumps I have checked.

- ☐ Hydreco Pumps
- ☐ Stratopower Pumps
- ☐ Dudco Pumps
- ☐ Kinney Liquid Handling Pumps
- ☐ Kinney Vacuum Pumps
- ☐ Aurora Pumps

Name .....

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City ..... State .....

Longer Bearing Service Assured!

PROMET
THE Engineered BRONZE

Bearings, bushings and wearing parts are machined or rough cast of the specific formula best suited to the application. American Crucible methods, experience, know-how and equipment result in highest quality bearings . . . bearings that carry a

MONEY-BACK GUARANTEE

of longer service, lower maintenance cost.

Write for literature or send blueprints, conditions of operation, etc. for quotations and recommendations as to alloys.

THE AMERICAN CRUCIBLE PRODUCTS CO.

1321 Oberlin Avenue
Lorain, Ohio, U. S. A.

New Machines

back and side guides by hand. Back guide is a plastic knob controlling the distance of the punched holes from the edge of the sheet; T-shaped side guide helps operator center sheets under punching dies. Number and location of holes can be varied by removing set pins located directly over each punch along the top of the machine. Size, 48 in. wide, 33 in. high, 18 in. deep; weight, 180 lb. *General Binding Corp., Chicago, Ill.*

Typewriter: Electri-conomy Dual-Rite produces bold or regular weight typing. For bold lines or words a Nylex ribbon rises mechanically in front of the customary paper carbon ribbon; increased ink deposit from added key impact due to double ribbon thickness and controlled "spread" of printed type produces nearly twice the boldness of regular typing. Shifting ribbon control key moves ribbon into position for bold typing. Typewriter also features electrified carriage return, adjustable key dip and choice of automatic repeat keys. *Remington Rand Inc., New York, N. Y.*

Plant Equipment

Portable Rivet Cooler: Self-contained refrigerator utilizes ½-hp condensing unit. Capacity, 48 lb of aluminum rivets; 48 individual rivet canisters and six canister racks store rivets. Refrigeration system operates automatically and will maintain a temperature as low as 30 F. Size: 40¾ in. high, 38⅝ in. long, 35½ in. wide. *Ace Cabinet Corp., New Bedford, Mass.*

Cutter Grinder: Vibration-free Model CG2 grinds cutters from any type of engraving or routing machine. Has a precision ball bearing spindle driven by an endless belt. Tool head is designed for spring collets; has a capacity of ½-in. diameter shank cutters. Equipped with an indexing device for grinding single-lip two, three and four-sided cutters. *New Hermes Engraving Machine Corp., New York, N. Y.*

Oil Reclaimers: For the purification and maintenance of transformer insulating oils. vacuum

VISCOUS ADHESIVE Pumped 7 Years without repairs to VIKING PUMPS

Installed in 1945, in the industrial adhesive manufacturing plant of F. G. Findley Company, Milwaukee, these two Viking Pumps have given maximum service with minimum attention and *without repair costs.* They have handled thousands of barrels of adhesives with viscosities from 100 cps to 3000 cps, with temperatures from 70 to 165 degrees F.

If you have the problem of moving heavy, viscous liquids—or any other liquids—Viking experience is available to help you. Write for bulletin 53SH.

VIKING PUMP COMPANY • CEDAR FALLS IOWA

THE ORIGINAL "GEAR-WITHIN-A-GEAR" ROTARY PUMP

Case History M-119

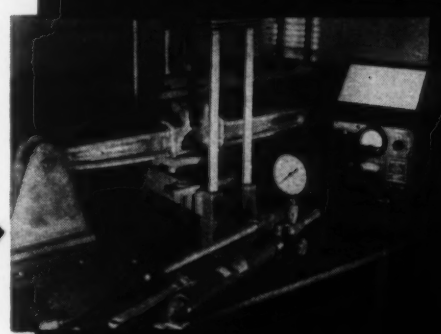
Here's what we mean by *SUPERIOR* ENGINEERED FOUNDRY PRODUCTS...

PROBLEM:

1. This 55-pound cast steel rear spring lock out beam was failing in service.
2. Because the design was not compatible with good foundry practice, it was impossible to consistently produce quality castings.
   (a) An excessive number of feeding risers was required to eliminate a shrinkage condition at the heavy rib junctions.
   (b) The long, deep, narrow pockets were the cause of sand being washed off and becoming trapped in the metal as the casting was being poured.

SOLUTION:

Stress analysis of the original design, in Superior's own stress analysis laboratory, revealed the stresses to be too high and the ribs to be stress risers. Therefore, the design must be modified in order to carry the service loads.



RESULT:

1. Superior's Engineered Foundry Design reduced the critical stress 57.5%, eliminating service failures. Strength was increased 235%, weight reduced 3.2 pounds.
2. The redesign is compatible with good foundry practice and enables the foundry to consistently produce castings that meet the high standards required.
   (a) Elimination of the heavy rib junctions reduces the number of feeding risers required to produce sound castings.
   (b) Trapping of sand in the metal during pouring is prevented because the deep pockets have been reduced.

IT PAYS TO PAY ATTENTION TO CASTING DESIGN

YOU, TOO, CAN BENEFIT BY CONSULTING SUPERIOR'S PRODUCT DEVELOPMENT SERVICE.

If it can be cast, Superior's service developes the best design in which to cast it. If it shouldn't be cast, Superior's service developes the reasons why.

SALES OFFICES: CHICAGO 4, 332 S. Michigan Ave., DETROIT 35, 18050 James Couzens Highway, ST. LOUIS, 9008 Harrison Ave., Brentwood 11, BUFFALO, 2107 Kensington Ave.

ENGINEERED FOUNDRY PRODUCTS

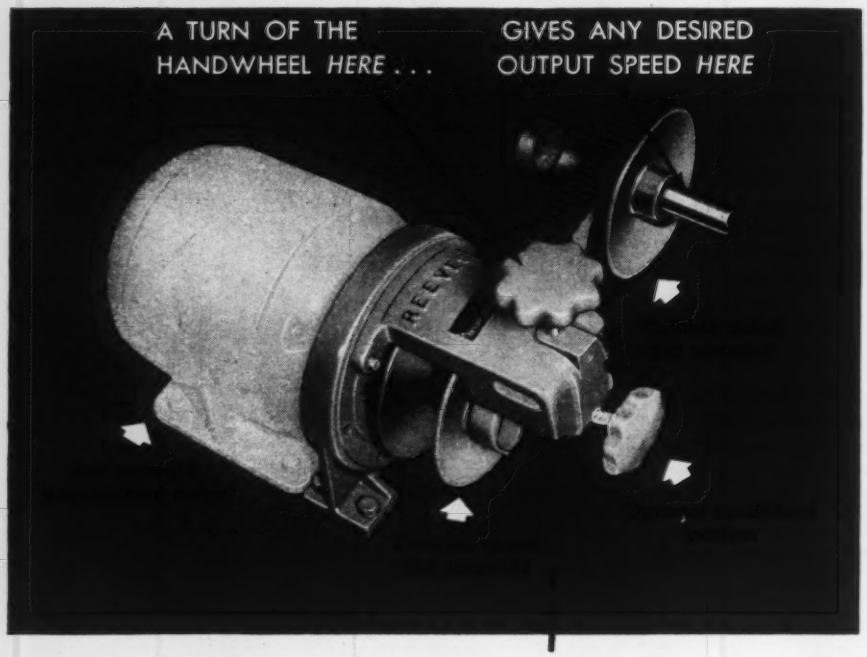
Since 1916

SUPERIOR STEEL AND MALLEABLE CASTINGS CO.

BENTON HARBOR, MICHIGAN, U. S. A.

NEW! REEVES
Flexi-Speed Drive

Mounts in any position . . . drives in any direction . . . gives any speed within 8:1 range. *Low Price!*



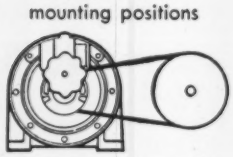
New REEVES Flexi-Speed Drive is the most versatile variable speed drive on the market today. Drives in any direction. Mounts in any position —above, below or beside the driven machine—practically without limitation. Speed control handwheel and driven shaft may be located anywhere around the motor shaft. Six different length belts offer a wide choice of shaft center distances.

For all these reasons, REEVES Flexi-Speed Drive is the easiest, most practical, and economical way of converting any constant speed motor to an infinitely variable speed drive *with 8:1 speed range*. May be used with any standard ball bearing, foot-mounted motor of ½, ¾ or 1 hp. Identical in working principle to the time-tested REEVES Motodrive, the Flexi-Speed Drive consists of constant speed disc assembly, variable speed disc assembly, double-cog belt and versatile shifting mechanism.

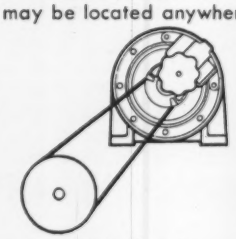
REEVES Flexi-Speed Drive is ideal for driving to standard gear reducers for parallel drive, on worm gear reducer for inexpensive right angle drive. Its versatility assures maximum production with the greatest efficiency and economy in your machines. Write today for complete details. Specify Dept. H90-V532.

REEVES PULLEY COMPANY, COLUMBUS, INDIANA

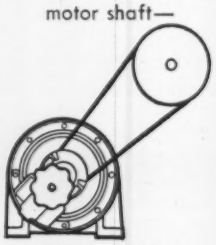
Some of the mounting positions



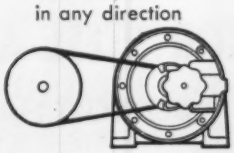
Handwheel control may be located anywhere



360° around motor shaft—



Belt may drive in any direction



REEVES SPEED CONTROL

pump lubricating and sealing oils, lubricating oils used in diesel and gasoline engines, and other types of industrial oils. Remove contaminants such as atmospheric dust, moisture, sand, scale and rust, which impair operating efficiency. Dirty oil is picked up by a pump, oil passes through the high capacity regenerative heat exchanger which picks up heat from hot outgoing oil and then to the filter where foreign matter is removed. After filtering, the oil passes to the vaporizer where it is heated under vacuum for removal of volatile materials. Clean oil is withdrawn from vaporizer by means of a pump and is passed out to receiving tanks or equipment. Available in capacities up to 500 gph. *The Hilliard Corp., Elmira, N. Y.*

Hydraulic Pumping Unit: For low gpm operation. Has all steel welded reservoir, Nitraloy gear pump in aluminum alloy case. Unit is piped with relief valve, check valve, reservoir filter and air breather filter. Produces pressures to 1200 psi; capacities, 0.8 to 2.8 gpm. Available with or without motor. *Hackett Brothers Inc., North Manchester, Ind.*

Portable Sand Blaster: Block Buster uses any clean, dry sand that will pass through a 16-gage screen, metal shots, flint shots, grit or finer sandblast sand. Has no moving parts or mixing chambers. Operates from any direct air line or compressor having 80 lb or more pressure. Average air consumption is 30 to 35 cfm, depending upon nozzle size and air pressure used. Pressure is adjustable from 30 to 120 lb. Removes concrete, rust, scale, paint and dirt from metals, stone, brick, wood, plastic or glass surfaces. Available in three models with sand capacities of 90, 150 and 200 lb. *Corson Co., Washington, D. C.*

Centrifugal Pumps: Fig. 3405 single stage, double suction series in capacities from 200 to 6400 gpm, with heads up to 260 ft. Feature renewable stuffing box bushings, sealed bearing housings, cowl type glands suitable for use with quenching liquids, stainless steel impeller keys, Teflon water seal rings, die-

Economy and Practicality are by-words with **Gibson** CONTACT RIVETS

Rivets cost less than other forms of electrical contacts and are easier to assemble . . .

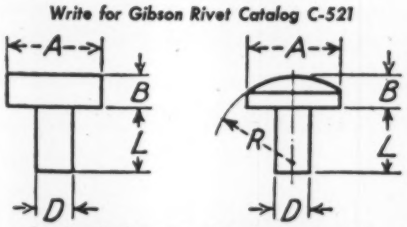
Gibson contact rivets are often the most appropriate and economical contacts for relays, switches, instruments and other applications involving small or moderate currents.

They are easy to install, are promptly supplied in standard or special sizes and shapes, and can be conveniently attached to springs or other supports at the Gibson plant — using supports furnished either by Gibson or the customer.

Moreover, Gibson contact rivets are readily available in fine silver, coin silver, or any electrical contact material capable of being cold-formed. Gibsiloy A-3, a case in point, combines all the advantages of silver with tougher wear resistance and reduced tendency to "freeze."

Let Gibson engineers recommend the best Gibson contact rivet for your needs. For rivet quotations, please submit dimensions (as shown below) and quantity desired.

Write for Gibson Rivet Catalog C-521



A = head diameter D = shank diameter
B = head thickness L = shank length
R = radius of face

CONTACT GIBSON FIRST

Gibsiloy ELECTRICAL CONTACTS

Manufactured by

GIBSON ELECTRIC COMPANY

8355 Frankstown Ave.
Pittsburgh 21, Pa.

New Machines

formed stuffing box packing and corrosion-resistant gland bolts. Compact; have short bearing spans. Casings are split horizontally for easy removal of upper half. Three assemblies of shafts and rotating parts have interchangeable parts, making possible 19 different pump sizes. Direction of impeller rotation can be changed without additional parts. Can be supplied with electric motor, belt or steam turbine drives. *Goulds Pumps Inc., Seneca Falls, N. Y.*

Woodworking

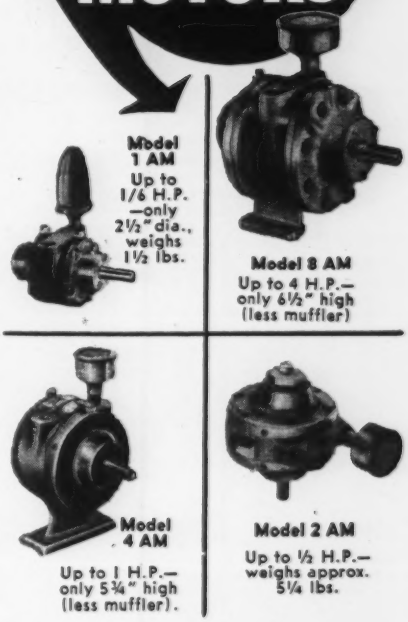
Turning Machine: Model 1000, for wood and plastics, has variable feed and cutterhead speed controls. Self-centering and equalizing stock guide eliminates chatter and vibration; blower type shaving hood exhausts chips from hood; redesigned drive system eliminates clutch and many gears and shafts, reduces need for lubrication and maintenance. *Hawker Mfg. Co., Dayton, O.*

Radial Arm Cutters: Redesigned line features radial arm 3 in. longer and a work table 3 in. wider and 4 in. longer than previous models. Can rip to the center of a 4-ft panel. Model MB machines are available in ½ and ¾ hp and can be left unmounted for portability. Model GW machines, made in ¾, 1 and 1½ hp, are equipped with angle-steel legs which bolt directly to machine frame. *DeWalt Inc., Lancaster, Pa.*

Electric Tool Kit: For sizing and triple-hinging doors and jambs. Includes high-speed portable electric router and electric plane, both of which use an interchangeable motor. Adjustable hinge-butt template; attachment for sharpening cutter; other attachments. Router also cuts mold edges, dadoes, etc. Plane can be adjusted for bevel planing or for use with weatherstrip cutters. *Porter-Cable Machine Co., Syracuse, N. Y.*

Correction: Manufacturer of the portable impact tool, described on Page 448 of the April issue, was listed incorrectly. This tool is made by Syntron Co., Homer City, Pa.

Get astonishing **POWER** and other unique advantages with **GAST** rotary **AIR MOTORS**


Model 1 AM
Up to 1/6 H.P. —only 2½" dia., weighs 1½ lbs.
Model 8 AM
Up to 4 H.P.— only 6½" high (less muffler)
Model 4 AM
Up to 1 H.P.— only 5¾" high (less muffler).
Model 2 AM
Up to ½ H.P.— weighs approx. 5¼ lbs.

FOR YOUR ORIGINAL EQUIPMENT APPLICATIONS . . .

Gast rotary-vane Air Motors may solve tough problems on **your** product! They're lower in first cost, variable in speed, explosion-proof, quick starting, **amazingly** compact and light compared to electric motors.

Four sizes available, reversible and non-reversible ball bearing types, several mounting styles, speeds to 12,000 RPM. Numerous accessories. "Air may be your Answer!"

Write Gast, stating your specific problem or mention model that interests you.

Original Equipment Manufacturers for Over 25 years

GAST ROTARY

AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)

GAST MANUFACTURING CORP., 109 Oakley St., Benton Harbor, Mich.